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BY

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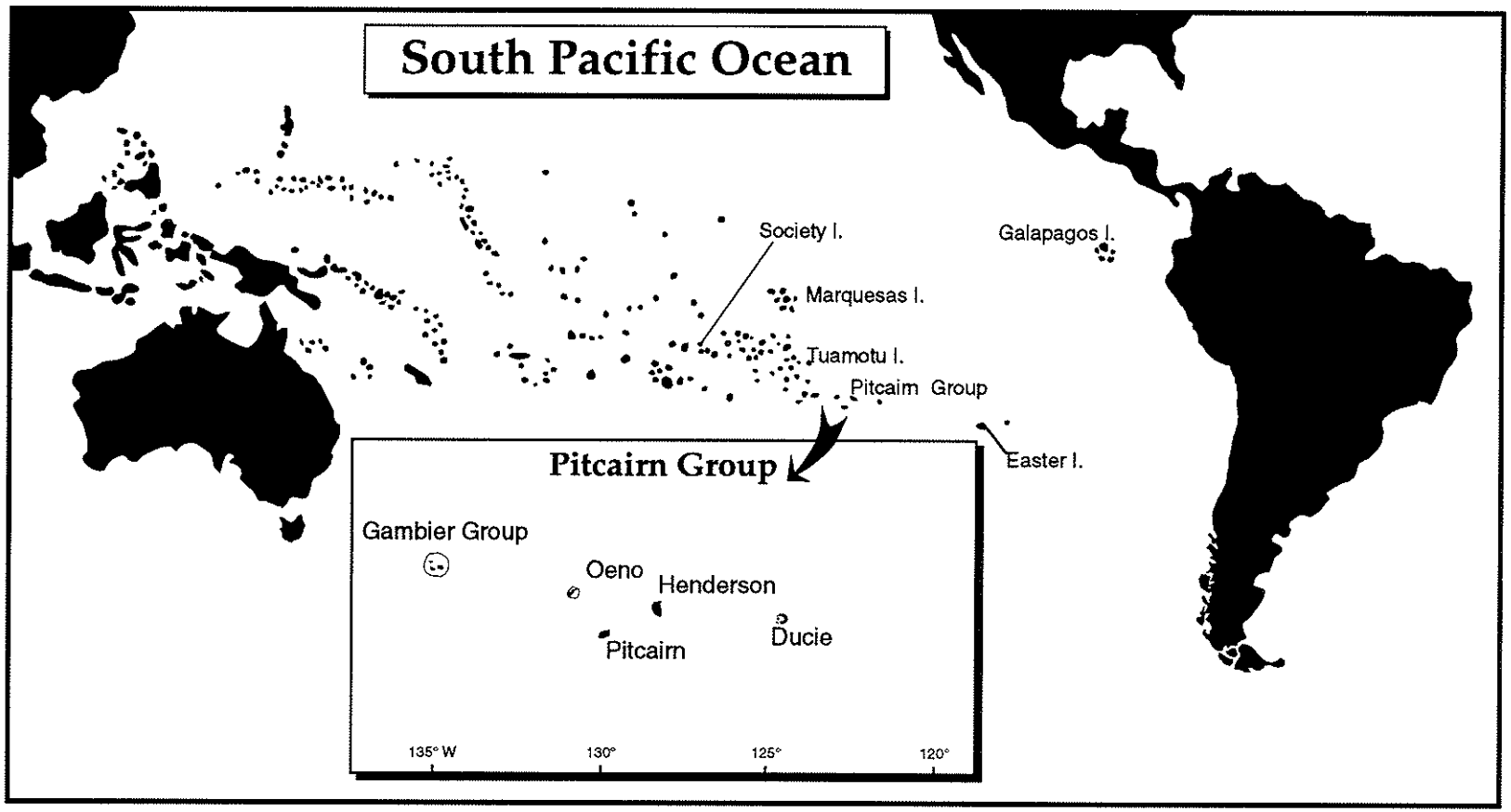
South Pacific Ocean
Society I.
Galapagos I.
Marquesas I.
Tuamotu I.
Pitcaim Group
Easter I.
Pitcairn Group
Gambier Group
Oeno
Henderson
Ducie
Pitcairn
135° W
130°
125°
120°

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BY

STEVE WALDREN[1], MARSHALL I. WEISLER[2], JON G. HATHER[3] AND DYLAN MORROW[4]

ABSTRACT

Henderson island, a World Heritage Site in the Pitcairn group, south-central Pacific Ocean, has often been thought to have a pristine vegetation. Our archaeological investigations and field observations in 1991-1992, supported by recent observations in 1997, suggest the occurrence of former areas of Polynesian cultivation near to the North and East Beaches, and indicate that about 17 non-native vascular plant taxa have occurred. The majority of these were deliberate Polynesian introductions, some taxa are known only as sub-fossils from Polynesian occupation sites; some of this sub-fossil material may represent imported plant parts such as timber or food wraps, rather than indicating *in situ* cultivation. These Polynesian introductions show little spread from their probable site of introduction and are mostly restricted to the vicinity of the northern beaches; some have become extinct on Henderson. The Pitcairn islanders have also introduced a small number of vascular plants, and one of these (*Passiflora maliformis*) is potentially invasive. Other taxa have been accidentally introduced, at least one by a recent scientific expedition in 1991. The intact nature of much of the native vegetation may have restricted the opportunities for more widespread colonization; care is needed to ensure that this situation persists.

INTRODUCTION

Henderson island (24°20' S, 123°20' W; 37 km^2) is one of four widely-separated islands of the Pitcairn group, lying east of the Tuamotu archipelago, near the southeastern margin of Polynesia. The island is a raised atoll (or *makatea* island) with the fossil reef surface now some 30 m above sea level, and most of the coastline is of sheer cliffs, often

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considerably undercut. The narrow beaches in the northern part of the island (Fig. 1) provide the only practical means of access from the sea. Apart from the beaches, Henderson is continuously vegetated, except for some bare patches of coral rubble in the former central lagoon patch reefs, and the areas of limestone pinnacles in the northwest (Waldren, Florence & Chepstow-Lusty, 1995b). There is no standing fresh water, although drips are found in the backs of some caves which last for several days after hard rains. The climate is essentially subtropical; data collected in 1991-1992 suggest a seasonal temperature range from a maximum of 31.4 °C (February, March) to a minimum of 12.0 °C (September), wind was predominantly from the east, but wind speed, direction and rainfall varied unpredictably throughout the recording period. For further climatic details see Spencer (1995).

Despite Henderson's hostile terrain and limited fresh water, the island's remoteness is probably the key factor that helps to preserve most of the native flora and fauna today. Of the 72 vascular plants recorded, 9 are considered endemic (Waldren, Florence & Chepstow-Lusty, 1995a). There are four endemic birds in addition to breeding populations of various seabirds, some of which are very locally distributed (Brooke, 1995). At least 300 terrestrial arthropods occur, many of which are endemic (Benton, 1995; Benton & Lehtinen, 1995), and Preece (1995) recorded at least 16 terrestrial molluscs, over half of which were considered endemic. These local or endemic taxa, the intact vegetation cover compared to other Pacific raised atolls, and the biogeographic importance of the island's position near the eastern extremity of the Indo West-Pacific biotic province (Kay, 1984) all contribute to the conservation value of the island, which has been designated a World Heritage Site.

The supposed pristine nature of the flora and fauna have attracted much attention (Diamond, 1995; Fosberg, Sachet & Stoddart, 1983). However, the North and East Beaches in particular are generally backed by cliffs with numerous caves and these have been utilised as occupation sites by Polynesian settlers, either transiently or continuously, between ca. AD 1050 and 1600 (Weisler, 1994, 1995, 1996, 1997). A major habitation midden was identified along the North Beach and measures at least 10,000 m^2 (Weisler, 1995, 1998). Although these caves and beach areas provided habitation loci for Polynesian groups, they explored much of the island as evidenced by a rock shelter at the remote southern end of the island (Weisler, 1995). Prehistoric gardening areas near the cliff margins on the north and east coasts, and much less on the northwest side of the island, bear evidence of shifting cultivation: stone clearance mounds and charcoal particles dispersed throughout subsoil dated, in some places, to the 13th century (Weisler, 1995). Localised burning for land clearance may have reduced habitat for land and sea birds (Wragg & Weisler, 1994), although direct predation (Weisler & Gargett, 1993) and the introduction of the Pacific rat (*Rattus exulans*) also contributed towards the extinction of certain bird taxa (Wragg & Weisler, 1994; Wragg, 1995).

Alteration of pristine islands throughout the course of human colonization and settlement is well documented (for recent summaries, see papers in Kirch & Hunt, 1997). Consistent with human colonization of Oceanic islands, Polynesian settlers of Henderson introduced new plant species for construction, medicinal and spiritual uses in addition to food. Along with the oceanic staples such as coconut *(Cocos nucifera),* both candlenut (*Aleurites moluccana*) and ti (*Cordyline fruticosa)* were particularly well documented in prehistoric cultural deposits on Henderson.

The Pitcairn islanders first visited Henderson in 1843, and continue to regularly collect the wood of *Thespesia populnea* and *Cordia subcordata,* used in carving curios.

The islanders have planted coconut in several places, especially at the west end of the North Beach, and have attempted to introduce a small number of other species, such as *Musa* sp. Other temporary visitors to the island include shipwrecked sailors (notably the crew of the *Essex*; see Fosberg *et al.*, 1983), visitors from passing yachts and pleasure cruises, and recent scientific expeditions. All of these, together with former Polynesian occupation, have affected the vegetation, and may have either deliberately or accidentally introduced plant species.

The *Sir Peter Scott Commemorative Expedition to the Pitcairn Islands* (PISE) visited Henderson for fifteen months during 1991-1992 with several objectives, including biological, archaeological and geological surveys (Benton & Spencer, 1995). A short visit to Henderson was also possible during the 1997 *Botanical and Entomological Expedition to Pitcairn*. The greater knowledge now available permits a more detailed understanding of the island's biota and ecology. The aim of this paper is to document the plant taxa introduced prehistorically by Polynesians and other plants species brought to the island after first European contact in 1606 (Quiros, 1904). It is often difficult to ascertain whether a taxon is native or introduced, and typically circumstantial evidence from the local distribution, dispersal mechanisms, potential use and biogeography must be balanced. We therefore provide notes on plant species, together with mapped distributions of the taxa; the latter may assist future scientific visitors to the island in updating information on the status of these taxa.

EVIDENCE FOR POLYNESIAN CULTIVATION AREAS

The archaeological evidence has been summarised by Weisler (1995). Two sites were located above the North Beach on the plateau, and two sites on the plateau above the East Beach (Figure 1). Local abundance of *Cordyline fruticosa* at these sites provides a useful marker, and may be a relict of cultivation. Surface gardening indications also included stone clearance mounds. Weisler excavated areas adjacent to these mounds and near the *Cordyline* stands revealing charcoal flecks dispersed through the subsurface sediments, which is typical of prehistoric gardening areas found elsewhere in the Pacific. The vegetation of the former gardening areas above the East Beach consists mostly of ferns, low shrubs and the weedy native *Senecio stokesii*. This suggests that once cleared of the typical forest dominated by *Pisonia grandis* (Waldren *et al.*, 1995b), full forest regeneration has not occurred after abandonment of the plots, possibly due to the harsh conditions, especially the onshore trade winds which buffet the East Beach and plateau. The general topography at these East Beach sites is a gentle slope towards the plateau margin and the sea; above the North Beach the plateau surface is more level, which has possibly favoured better forest regeneration by reducing exposure.

LIST OF NON-NATIVE TAXA

Achyranthes aspera var. *pubescens* (Moq.) Townsend (Amaranthaceae)

This taxon has only been recorded from a very limited part of the plateau forest about 1 km south of the North Beach (Fig. 2a). It is possibly a Polynesian introduction, but as it is absent from many areas of known Polynesian activity, it may be native or at least a casual introduction. The fruit is strongly reflexed at maturity and readily attaches to clothing or birds feathers (Fosberg & Renvoize, 1980). *A. aspera* var. *aspera* has been

recorded on nearby Pitcairn (St. John, 1987); in 1991 it was recorded at a single site and presumed a Polynesian introduction (Florence, Waldren & Chepstow-Lusty, 1995) although it could not be found on Pitcairn in 1997 (S. Waldren & N. Kingston, unpublished data). A similar uncertainty holds for Tonga where the plant has been used medicinally against infections (Whistler, 1991a), it was also used medicinally in Samoa and Niue (Uhe, 1974; Whistler, 1984; Göthesson, 1997). Given the relatively few references to this species in Polynesian ethnobotany, it seems likely that it may have been introduced passively by Polynesian visitors or more probably by birds to Henderson; St. John & Philipson (1962) consider *A. aspera* an accidental introduction.

***Aleurites moluccana* (L.) Willd. (Euphorbiaceae)**

This species was collected by the Whitney expedition in 1922, but has not been seen since despite extensive collecting by St. John and Fosberg in 1934 during the Mangarevan Expedition (St. John & Philipson, 1962), or during the PISE (Florence *et al.*, 1995). However, during a brief visit to Henderson in 1997 fragments of periderm ('shell') were found on the strand line of North Beach by J. Starmer and S. Waldren; searches of the North Beach embayment forests again failed to locate a living specimen of this obvious species. *A. moluccana* is native to S.E. Asia and aboriginally introduced throughout Polynesia (Whistler, 1991b). Handy & Handy (1972) claim that the large nut does not float and is not 'resistant' to sea or fresh water. It was probably introduced to Henderson by Polynesians as it had many uses: the seed has a high oil content, and was used widely as a source of oil and burnt on skewers for light (Handy & Handy, 1972). The soot from burnt nuts was an important dye (Handy & Handy, 1972; Whistler, 1991a,b), the inner bark juice yielded a reddish-brown dye (Göthesson, 1997), and the plant had various uses in Polynesian medicine (Barrau, 1961; Cox, 1991; Göthesson, 1997). Shell fragments were found in cultural deposits in rock shelters on the North and East Beach (Fig. 2b) dating from as early as AD 1290 to 1440 (Weisler, 1995: Table 2: Beta-45598). Candlenuts were also burnt on Pitcairn island as a source of light (R. Warren, pers. comm.), and it is possible that the tree(s) found in 1922 were introduced by early visitors from Pitcairn, as claimed by St. John & Philipson (1962).

***Barringtonia asiatica* (L.) Kurz (Leycithidaceae)**

B. asiatica is a widespread strand plant which is probably a Polynesian introduction to the Pitcairn group. It still occurs, albeit in small numbers, in the vicinity of Adamstown on Pitcairn, but living plants have never been recorded from Henderson. The fibrous fruits readily float in seawater and are commonly found on drift lines, however Whistler (1991) suggests it may be a Polynesian introduction to atolls although it is native on rocky coasts as far east as the Marquesas. Crushed or grated fruits were widely used as a fish poison (Brown, 1935; Whistler, 1991b), and the timber used for light construction (Banack & Cox, 1987), canoes (Brown, 1935) and also for firewood. The fruits were also used as floats for fishing nets (Brown, 1935). Wood specimens were identified from an East Beach rock shelter (Fig. 2c) with associated dates between AD 1330 to 1650 (Weisler 1995: Table 2: Beta-45600).

***Cocos nucifera* L. (Arecaceae)**

Coconuts occur in well established groves on the North and Northwest beaches (Fig. 2d). There is a small grove on top of the plateau at the North Beach directly opposite the reef pass, and a few small individuals scattered elsewhere about the North Beach plateau margin. There are a few recent plantings on the East Beach, and a few isolated individuals occur in the plateau forest, one juvenile specimen was found 4 km from the North Beach and may represent an ecologically unsound marker for the end of someone's trail (Operation Raleigh?): these were destroyed when found in 1991-1992. In

addition, fruits of *Cocos* and *Thespesia* were scattered from a helicopter over the northern part of the plateau forest in 1966 during an American airfield survey (M. Fraser, pers. comm.); fortunately few if any seem to have survived.

C. nucifera is probably native to the Old World tropics, but has been extensively naturalised throughout the tropics, often leading to secondary colonization or local spread. The species was aboriginally introduced to Polynesia, where it remains a plant of major economic importance (Whistler, 1991a). Although Kirch (1991) lists it as a non-staple throughout Polynesia, coconut was undoubtedly a major staple food on Polynesian and Micronesian atolls, though of less importance on high islands (Barrau, 1961). It has a wide variety of other uses, including beverage, cordage, matting, thatch and timber (Kirch & Yen, 1982; Whistler, 1991a). It was most likely brought to Henderson by Polynesian settlers as the shell, wood, and husk of the plant was identified at several sites on the North and East beaches. The earliest associated radiocarbon dates are calibrated between AD 1000 to 1390 (Weisler, 1995: Table 2: Beta-59983). However, plants introduced by Polynesians may well have died out or at least become very rare. Captain Beechey, who visited in the *Blossom* in 1825, did not mention this obvious tree but stated that the tallest trees, and the only ones to yield edible fruit, were *Pandanus* (Fosberg *et al.*, 1983). Coconuts were introduced during the first visit by the Pitcairn islanders in 1843 (Fosberg *et al.*, 1983), the current groves of coconut on Henderson probably derive entirely from plantings made by Pitcairn islanders supplemented with some local dispersal.

***Cordia subcordata* Lam. (Boraginaceae)**

On Henderson this species is restricted to forests occupying the sandy areas behind the dunes of the North and East Beaches (Fig. 2e); *Cordia* is apparently absent from similar habitats at the Northwest Beach. A widespread Indo-Pacific strand plant, the seeds are dispersed by flotation (Fosberg & Renvoize, 1980), and so the species might possibly be native. However, Whistler (1991b) claims it is an aboriginal introduction in the eastern part of its range, including Hawai'i. The nuts are eaten in the Tuamotu islands and elsewhere, mostly in times of famine (Barrau, 1961; Whistler, 1992), and the leaves provide occasional food on Tikopia (Kirch & Yen, 1982), but the main value of the plant is for its beautiful finely grained timber which is highly valued for construction of houses, boat parts and for various artefacts and handicrafts (Whistler, 1991a, 1992). The inner bark fibres have been used in weaving, and various parts of the plant have been used medicinally (Whistler, 1992). The attractive orange flowers may also have been used by Polynesians for making *lei*. Pitcairn islanders have regularly harvested *Cordia* from Henderson for use in their wood carving industry; the few large trees seen on the North Beach in 1991 had all been removed by 1997, although smaller trees still occur on the cliff slopes of the North and East beaches. Probably a Polynesian introduction, but see also comments on *Thespesia populnea* below, which occurs in similar habitats.

***Cordyline fruticosa* (L.) Chev. (Agavaceae)**

Cordyline is largely restricted to the plateau margin (Fig. 2f). It occurs at the top of the cliff directly above most caves which have prehistoric Polynesian occupation on the North Beach. It is less frequent at the East Beach, and occurs several hundred meters inland from the cliff edge, possibly marking former cultivation areas. There are isolated groups of plants on the plateau margin along the east coast, and at the northwest point. There is also one large grove of individuals at the North Beach just below the cliff at the site of the PISE camp, this location was the earliest habitation site on Henderson (Weisler, 1995). Leaves and wood of *Cordyline* were found in several rock shelters on

the North and East beaches with earliest associated dates between AD 1330 to 1650 (Weisler, 1995: Table 2: Beta-45600).

C. fruticosa is probably native to tropical Asia and is an aboriginal introduction to Polynesia (Whistler, 1991b). Handy & Handy (1972) claim it to be native to Hawai'i, but this is highly unlikely and the species was treated as a Polynesian introduction by Wagner, Herbst & Sohmer (1990). It is widespread throughout Polynesia, and many cultivars are known, for example those with red leaves which may be grown purely for ornament. The roots were widely used as a sugar source (Whistler, 1991a), containing ~20% sucrose according to Barrau (1961), who also states that cooked roots keep well. The leaves were used as food wraps, cordage and clothing, and the plant was used in herbal medicine (Handy & Handy, 1972; Kirch & Yen, 1982; Whistler, 1991a; Whistler, 1991b), but *Cordyline* also had great religious significance (Whistler, 1991b). For example, in Hawai'i the plant was used for altar decoration, protection from evil spirits and for exorcism (Handy & Handy, 1972), and perhaps of more significance to Henderson, was used as a boundary marker in Tikopia (Kirch & Yen, 1982). *Cordyline* observed in 1997 growing high on the cliffs at Tautama, the major stone quarrying area of Pitcairn, may well have been planted for similar marker/religious purposes. The distribution of *Cordyline* on Henderson suggests it was used as a food supplement and is often found at gardening locations (Weisler *et al.*, 1991), and the plant probably had great religious and cultural significance. No flowering or fruiting has ever been recorded from Henderson *Cordyline*, which may represent a sterile cultivar resulting from a single Polynesian introduction; nearby Pitcairn has many fully fertile individuals.

***Cyrtosperma chamissonis* (Schott) Merr. (Araceae)**

Cyrtosperma is known from Henderson as subfossil leaf material from two rock shelters on the North Beach; it is absent from the modern flora and it is possible that it never grew on the island. The Henderson specimens were found in prehistoric cultural deposits associated with earth ovens (Fig. 2g) dated from AD 1330 to 1648 (Weisler, 1995: Table 2: Beta-59009). Indeed, *Cyrtosperma* leaves were often used to wrap items for transport and to cover earth ovens during cooking. The species is native to New Guinea, but aboriginally introduced to Polynesia (Whistler, 1991b). Aroid tubers remain an important starch source, but *Cyrtosperma* was of less importance than *Colocasia esculenta* (Kirch, 1991; Whistler, 1991b)—at least on high volcanic islands. However, its ability to grow in brackish water made it a major staple on atolls (Barrau, 1961), although at least some cultivars can grow readily in drier conditions, as on Tikopia (Kirch & Yen, 1982). The occurrence of leaf material suggests it was cultivated *in situ*, although leaves may possibly have been imported from Pitcairn or Mangareva.

***Hedyotis romanzoffiensis* (Chamisso & Schlechtendal) Fosberg (Rubiaceae)**

A specimen of this species with immature fruit was first found in 1997 by S. Waldren, who had previously collected seed from the Oeno island population (St. John & Philipson, 1960) in 1991. The species was found growing in a sandy substrate slightly east of the Pitcairners camp at North Beach, in an area used for drying seed in 1991 (Fig. 2h). As the plant was growing in an appropriate ecological niche, and as Henderson is within the natural range of the species, the individual plant was not removed. A sample of leaf tissue was dried in silica gel for DNA extraction to allow any colonization by the taxon to be followed genetically.

Hernandia sp.

Hernandia stokesii occurs as a supposedly native species on Henderson, and is restricted to the highly dissected makatea inland from the Northwest Beach (Fig. 2i). It may be conspecific with *H. sonora* which occurs in many of the valleys on Pitcairn, where its status is uncertain. As with many of the other fossil timbers, it is not clear whether this represents a Polynesian introduction of timber extracted elsewhere, or whether plants were grown on Henderson. The light timber was used for outrigger floats (Banack & Cox, 1987), and was until recently used for making light fishing canoes on Pitcairn (Reynold Warren, pers. comm.); other *Hernandia* species have been similarly used in the Marquesas (Brown, 1935). Charred wood of a *Hernandia* species was recovered from an East Beach rock shelter with an associated date of AD 1330 to 1650 (Weisler, 1995: Table 2: Beta-4560). Although it is possible that Polynesians may have caused the local extinction of this species from the vicinity of the East Beach, it seems more likely that the wood was imported from elsewhere, possibly from Pitcairn. It is unlikely that the Polynesians were exploiting the native *H. stokesii* which has a highly restricted distribution.

Hibiscus tiliaceus (Malvaceae)

H. tiliaceus is widespread in Polynesian coastal forests, including Pitcairn (Florence *et al.*, 1995; S. Waldren & N. Kingston, unpublished data). The species has never previously been recorded from Henderson; as there have been few archaeological records and no modern records, we consider the Henderson material may be of Polynesian origin. However, Wagner *et al.* (1990) considered this species as indigenous to the Hawai'ian and Marquesas islands, and it may well have been native to Henderson. Also, it is not clear whether the fossil Henderson material represents imported wood, or whether it was of local origin. Identified from charred wood from an East Beach rock shelter (Fig. 2j) with an associated date of AD 1280 to 1430 (Weisler, 1995: Table 2: Beta-45601). The inner bark fibers were used as cordage (Brown, 1935; Banack, 1991; Whistler, 1991b), and the light timber used for construction of floats for canoes (Banack, 1991) and fishing nets (Whistler, 1992); the species was also used medicinally (Brown, 1935; Cox, 1991; Whistler 1992). The large leaves served as plates or food wraps (Brown, 1935); on Pitcairn they have occasionally been used as a substitute for toilet paper (Meralda Warren, pers. comm).

Lycopersicon esculentum Mill. (Solanaceae)

A few tomato plants have on occasion been introduced by the Pitcairn islanders; none seems to have survived in the sandy soils of the North Beach area for very long (Fig. 2k).

Musa sp. (Musaceae)

Bananas have been introduced by the Pitcairners but, like tomato, they do not persist for long. In 1991-1992 one was growing in an oil drum 'pot' near the North Beach landing, it was absent in 1997; it is unlikely that the plant would survive to produce fruit on Henderson. The large leaves are used to wrap food for transport, for cooking, and for covering earth ovens, while the fruit provides an important food. Leaves of *Musa* sp. were identified at an East Beach site (Fig. 2l) with an associated date of AD 1410 to 1660 (Weisler, 1995: Table 2: Beta-45602). It is not clear whether the sub-fossil material from Henderson represents food wraps brought from outside; it is likely that Polynesian settlers brought living plants with them, but these failed to persist.

Pandanus tectorius Parkinson (Pandanaceae)

Pandanus groves occur throughout Henderson (distribution not mapped), from the most hostile locations on the southwestern cliffs, to the shelter of the mixed *Pisonia*

forest of the plateau. St John described many local species of *Pandanus*, including *P. hendersonensis*, but these are all currently considered to be part of *P. tectorius*. There is considerable variation present between the Henderson individuals, although each grove seems to be reasonably uniform. *P. tectorius* is widespread through the Indo-Pacific region (Fosberg & Renvoize, 1980).

The status of *Pandanus* on Henderson is difficult to ascertain. The fruits are naturally dispersed by sea and the seed may remain viable after flotation in seawater for eight weeks (Fosberg & Renvoize, 1980), so there is likely to be a native population on Henderson. However, the species was of great importance to Polynesians and had a great many uses. Timber was used for house frames (Whistler, 1991a), although in Hawai'i male trees are claimed to yield better timber than females (Handy & Handy, 1972). The leaves were used for thatch and, after removing thorns, for fine weaving (Handy & Handy, 1972; Whistler, 1991b), as they still are on Pitcairn island. Pollen was used to scent oil (Whistler 1992), and the leaves (Uhe, 1974) and aerial roots (Handy & Handy, 1972; Whistler, 1991b) were used medicinally. The plant was eaten in various ways in Polynesia (Handy & Handy, 1972; Whistler, 1991a), probably most often as a famine food (Whistler, 1991b). The soft base of the phalange was eaten as was the small seed in each fruit, and the hearts of the terminal branches were eaten after steeping in seawater to remove calcium oxalate (Barrau, 1961). As with *Aleurites* and *Cocos*, it is almost certain that Polynesians colonising or even visiting Henderson would have brought *Pandanus* with them, because of its great value. Introduced Polynesian cultivars may have integrated with the existing native population, resulting in a wide spectrum of morphological variation. Fosberg has suggested that variation in *P. tectorius* resembles that found in a highly variable horticultural species such as apple (Barrau, 1961).

***Passiflora maliformis* L. (Passifloraceae)**

Passiflora maliformis was seen at the eastern end of the North Beach in 1991 (Fig. 2k; Florence *et al.*, 1995), and empty fruits found washed up on North Beach in 1997. It is a recent deliberate introduction from Pitcairn island, where the species is invasive (Florence *et al.*, 1995). Various *Passiflora* species have become invasive weeds throughout the tropics; efforts should be made to eliminate this species from Henderson.

***Solanum americanum* P. Miller (Solanaceae)**

Solanum americanum was first recorded from Henderson in 1991 from the southern cliffs (Fig. 2n; Florence *et al.*, 1995). As this site is very remote from the access points in the north of the island, it may have been previously overlooked. However, as only a single plant was found, it is likely to be a recent colonist, probably by an avian vector. The species is a widespread weed (Barrau, 1961), and is common in the littoral vegetation of Pitcairn, but it is unlikely to have been introduced by Pitcairn islanders who never visit the southern part of Henderson. A Polynesian rock shelter occurs in the vicinity of the Henderson plant, and as the plant is sometimes used as a vegetable (Barrau, 1961; Whistler, 1991a) and been used medicinally (Göthesson, 1997), it may represent a Polynesian introduction, though we consider this species to be a recent and probably ephemeral colonist.

***Setaria verticillata* (L.) Beauv. (Poaceae)**

This species was recorded in 1987 and 1991-1992 from the North Beach landing area (Fig. 2n). It is a widespread tropical and subtropical weed, common on nearby Pitcairn from where the Henderson material probably originated. The fruiting spikelets have bristles with reflexed teeth that readily attach to clothing. All plants seen of this recent colonist were destroyed, and it could not be found in 1997.

***Thespesia populnea* (L.) Solander ex Correa (Malvaceae)**

On Henderson *Thespesia* is found in the embayment forests of the North and Northwest beaches (Fig. 2o) and is an important member of the vegetation there, associated with *Pisonia grandis, Celtis pacifica, Glochidion pitcairnense* etc; it is apparently absent from the plateau forests (Waldren *et al.*, 1995b). The fruit is an indehiscent capsule; the seeds, and presumably the fruits too, are capable of flotation for two months in seawater (Morrow, 1993), and this is likely to be a major means of dispersal. On Henderson, the seeds and fruit were ignored by rats (*Rattus exulans*) and species of hermit crab, probably because of toxic substances present in the seed and fruit. The native range of this species is uncertain because of aboriginal introductions; it is thought to be introduced to the eastern parts of Polynesia (Handy & Handy, 1972, Whistler 1991a) and Easter Island (Zizka, 1991). It may have originally been native to S.E. Asia (Zizka, 1991), but is now pantropic (Fosberg & Renvoize, 1980).

Thespesia had a variety of uses in Polynesian culture. Bark and leaf extracts were used for treating a variety of ailments (Whistler, 1991b). Trees were often planted around *marae* (temples) and it may have been important as a sacred tree (Wagner *et al.*, 1990). The species was used in Polynesian herbal medicine (Cox, 1991), mainly used topically or taken internally for intestinal disorders (Morrow, 1997). Various preparations of leaves, bark and heartwood have shown antibacterial, antifungal and antispasmodic pharmacological activity (Morrow, 1997). The wood is hard and durable, and was widely used for construction of durable items, such as bowls and canoe paddles (Whistler, 1991a,b). The yellow flowers are attractive and may have been used by Polynesians for decoration, particularly on Henderson where few species have large or showy flowers. The delicately coloured wood is still used for carving curios in Polynesia, including Easter Island (Zizka, 1991) and Pitcairn. Pitcairners regularly visit Henderson to cut both *Thespesia* and *Cordia*, the main timbers used on Pitcairn for carvings. The islanders prefer the *Thespesia* of Henderson to that of Pitcairn because the heartwood is more intensely coloured. At present it is likely that *Thespesia* and *Cordia* are harvested non-sustainably from Henderson.

The typical habitat of the species is coastal forests and the species is restricted to this habitat on Henderson, suggesting it may be native. On nearby Pitcairn island *Thespesia* occurs in a variety of habitats and is much more obviously introduced. Like *Cordia* and *Pandanus*, *Thespesia* may well have been introduced to Henderson by Polynesian settlers, but this does not preclude the existence of native populations.

***Thuarea involuta* (G. Forster) R. Brown**

This beach grass may be a Polynesian weed, but we consider it more likely to be native, despite sometimes being used ceremonially on Tonga (Whistler, 1992; Göthesson, 1997). It occurs in two distinct habitats: among shrubs along beach fronts at the East and North Beaches, and in coral rubble in fairly open inland *Xylosma suaveolens* forest south of the North Beach (Fig. 2p).

DISCUSSION

Of the 17 or so species that definitely or possibly are not native to Henderson island, two are considered to be recent adventives, three or possibly five to be deliberate introductions by the people of Pitcairn island, up to ten are deliberate prehistoric Polynesian introductions, and one is a possible accidental Polynesian introduction. One of the recent adventives (*Solanum americanum*) probably arrived on the island following

avian dispersal, possibly from Pitcairn island where the species is common. If so, this represents natural secondary dispersal of a weedy non-native species. The same may also hold true for *Cocos*, *Cordia*, *Hibiscus* and *Thespesia*, whose fruits are naturally dispersed by flotation on seawater, but are considered by many to be aboriginal introductions to eastern Polynesia. Three taxa (*Barringtonia, Cyrtosperma,* and *Hibiscus*) are known from Henderson only as subfossil material. Randy Christian and Meralda Warren of Pitcairn claim to have found a *Piper* species on Henderson; this requires further investigation. The identification of subfossil leaves, fruit fragments and wood has added greatly to our understanding of human plant introductions to Henderson and permits a more complete appraisal of the historical relationships between people and plants on isolated *makatea* islands.

There is clear evidence that Polynesian settlers deliberately introduced plants to Henderson island, and they doubtless had very good reasons for doing so. The first settlers would have found few indigenous plants that could be used as food and were probably known to the settlers; these included the leaves of *Lepidium bidentatum* and *Pisonia grandis*, and the stem bases of *Portulaca lutea* which can be eaten as a vegetable (Barrau, 1961), but these are at best occasional or famine foods and not major staples. Even on larger and floristically more diverse islands such as in Tonga, there are few native food plants (Whistler, 1991b). The earliest Polynesian visitors to Henderson may well have been transient harvesters of the previously untapped sea bird colonies and abundant marine resources such as fish, shellfish, and turtles, with permanent settlement occurring at a later time. The need for starch sources probably led to the introduction of *Cordyline* which also served for clothing and religious purposes. Certain medicinal plants may not have been available locally, and the settlers would doubtless have introduced cultivated forms of species with multiple uses, such as *Cocos* and *Pandanus*. As suggested earlier, the introduction of cultigens alongside an existing native population has probably lead to the present range of morphological variation in *Pandanus*. Probably a variety of cultivars best suited to particular uses were grown. At some period during the Polynesian occupation of Henderson extensive permanent habitations were utilised, and this probably coincided with direct production of crops from gardens. It is clear that the Polynesian settlers introduced a variety of plants which could provide food, timber, clothing, cordage, and medicines; further evidence of carefully planned voyages for settlement.

The settlers may have accidentally introduced weed species such as *Achyranthes aspera* and *Thuarea involuta*, although the species might equally well have arrived following adherence to birds feathers and the caryopses of the latter are probably capable of flotation. It is difficult to determine whether certain taxa are native or aboriginal introductions. *Thespesia populnea* and *Cordia subcordata* may possibly have been present on Henderson prior to initial Polynesian contact, although they are widely considered to be aboriginal introductions in eastern Polynesia (Handy & Handy, 1972; Whistler, 1991b; Whistler, 1991a; Zizka, 1991). Even if these do represent Polynesian introductions, they have integrated with existing beach forest vegetation although they have not spread to the plateau.

None of the known or suspected Polynesian introductions are currently invasive, and all are more or less restricted to the northern end of the island, where the highest densities of prehistoric Polynesian habitations are found. This may be because the native vegetation has seen little disturbance over most of the island, thereby restricting the opportunities for successful spread of weedy species. Two other species, considered to be native, are also restricted to the north of the island, these are *Caesalpinia bonduc* and

Senna glanduligera. *Caesalpinia* has limited Polynesian uses, mainly as a snare for birds or fruit bats (Whistler, 1984, 1991a), while *Senna* spp. (and the related genus *Cassia*) are known to have purgative properties. Both species are dispersed by sea, the indehiscent lomentum of *Senna* floats, and although the very hard seeds of *Caesalpinia* are not buoyant, the pod probably is and accounts for sea dispersal claimed by Fosberg & Revoize (1980). Both these species are likely to have washed up on the northern beaches, and their subsequent spread south would have been slow as biotic dispersal is likely to be minimal.

Polynesian activities do not seem to have had a major effect on the vegetation of the island. Even the known garden areas have become completely invaded by native species, although forest communities have failed to develop on these sites. There is also little evidence to suggest that Polynesian activities caused the local extinction of native plant species, unlike the situation with birds (Wragg & Weisler, 1994; Wragg, 1995); the fossil evidence of *Hibiscus tiliaceus* in the absence of any living records may be the exception. Polynesian settlers utilised some of the native trees, as evidenced by the presence of charred wood of *Nesoluma* sp. (Fig. 2m), presumably the endemic *N. st-johnianum* Lam & Meeuse, at the East Beach (Hen 10) with an associated age of AD 1330-1650 (Beta-45600). The more recent effects of excessive cutting of *Thespesia* by American personnel during an airfield survey have had a much greater impact on the vegetation: areas of beach embayment forest at the North Beach have been colonised by *Pandanus*, leaving numerous cut *Thespesia* stumps in the deep leaf litter.

Recent introductions by the Pitcairn islanders are restricted to food plants, partly as an emergency in case bad weather necessitates a prolonged stay on Henderson. Some of these introductions are potentially invasive, and may damage the native communities. There are now well established groves of coconut at the North and Northwest beaches, and these seem to be invading coastal forest and dune ridge communities. The presence of *Passiflora maliformis* and *Setaria verticillata* indicates the potential problem of weedy species being deliberately or accidentally introduced to Henderson. Both these species are invasive weeds on Pitcairn, and their spread on Henderson should be monitored closely. Thankfully the efforts of the PISE in 1991-1992 seem to have eradicated *Setaria*, although the botanical phase of the expedition can be rather embarrassingly held responsible for the accidental introduction of *Hedyotis* from Oeno. Pitcairn has a considerably larger non-native flora than Henderson, most of which are relatively recent introductions, and some are highly invasive. As pointed out previously (Waldren *et al.*, 1995a), great care should be taken to prevent their spread to Henderson.

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REFERENCES

Banack SA 1991 Plants and Polynesian voyaging. In: Cox PA and Banack SA, eds, *Islands, Plants and Polynesians. An Introduction to Polynesian Ethnobotany*, pp.25-39. Dioscorides Press: Portland, Oregon.

Banack SA and Cox PA 1987 Ethnobotany of ocean-going canoes in Lau, Fiji. *Economic Botany* **41**:148-162.

Barrau J 1961 Subsistence agriculture in Polynesia and Micronesia. *Bernice P. Bishop Museum Bulletin* **223**:1-94.

Benton TG 1995 Biodiversity and biogeography of Henderson Island's insects. *Biological Journal of the Linnean Society*, **56:** 245-259.

Benton TG and Lehtinen PT 1995 Biodiversity and origin of the non-flying terrestrial arthropods of Henderson Island. *Biological Journal of the Linnean Society*, **56:** 262-272.

Benton TG and Spencer T 1995 *The Pitcairn Islands: Biogeography, Ecology and Prehistory*, 422 + xxxi pp. Academic Press.: London, U.K.

Brooke M de L 1995 The modern avifauna of the Pitcairn Islands. *Biological Journal of the Linnean Society*, **56:** 199-212.

Brown FBH 1935 Flora of Southeastern Polynesia. III. Dicotyledons. *B.P. Bishop Museum Bulletin*, **130:** 1-386.

Cox PA 1991 Polynesian herbal medicine. In: Cox PA and Banack SA, eds, *Islands, Plants and Polynesians. An Introduction to Polynesian Ethnobotany*, pp. 147-168. Dioscorides Press: Portland, Oregon.

Diamond J 1995 Introduction to the exploration of the Pitcairn Islands. *Biological Journal of the Linnean Society*, **56:** 1-5.

Florence J, Waldren S and Chepstow-Lusty AJ 1995 The flora of the Pitcairn Islands: a review. *Biological Journal of the Linnean Society*, **56:** 79-119.

Fosberg FR and Renvoize SA 1980 *The Flora of Aldabra and Neighbouring Islands.*, 358 pp. HMSO: London.

Fosberg FR, Sachet M-H and Stoddart DR 1983 Henderson Island (South eastern Polynesia): summary of current knowledge. *Atoll Research Bulletin*, **272:** 1-47.

Göthesson, L-Å 1997 *Plants of the Pitcairn Islands Including Local Names and Uses*, 394 pp. Centre for South Pacific Studies, University of New South Wales: Sydney.

Handy ESC and Handy EG 1972 Native planters in old Hawaii. Their life, lore and environment. *Bernice P. Bishop Museum Bulletin*, **233:** 1-641.

Kay A 1984 Patterns of speciation in the Indo-West Pacific. In: Radovsky FJ, Raven PH and Somer SH, eds, *Biogeography of the Tropical Pacific: Proceedings of a Symposium.* pp. 15-31. Bernice P. Bishop Museum: Honolulu.

Kirch PV 1991 Polynesian agricultural systems. In: Cox PA and Banack SA, eds, *Islands, Plants and Polynesians. An Introduction to Polynesian Ethnobotany*, 113-133. Dioscorides Press: Portland, Oregon.

Kirch PV and Hunt TL 1997 *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change,* 331 + XV pp. Yale University Press: New Haven.

Kirch PV and Yen DE 1982 Tikopia. The prehistory and ecology of a Polynesian outlier. *Bernice P. Bishop Museum Bulletin*, **238:** 1-396.

Morrow D 1993 *The Biology of* Thespesia populnea *and its use by the Pitcairn Islanders*. Unpublished B.A. (Mod.) thesis, University of Dublin.

Morrow D 1997 *Evaluation of the ethnomedicinal uses of* Thespesia populnea *(L.) Sol. ex Correa, using screens to isolate bioactive principles.* Unpublished Ph.D. thesis, University of Dublin.

Preece RC 1995 Systematic review of the land snails of the Pitcairn Islands. *Biological Journal of the Linnean Society*, **56:** 273-307.

Quiros PF de 1904 *The Voyages of Pedro Fernandez de Quiros, 1595-1606.* 2 volumes, translated by C. Markham. Hakluyt Society: London.

Spencer T 1995 The Pitcairn Islands, South Pacific Ocean: plate tectonics and climatic contexts. *Biological Journal of the Linnean Society*, **56:** 13-42.

St. John H 1987 *An account of the flora of Pitcairn Island with new* Pandanus *species,* 65 pp. Privately published: Honolulu, Hawai'i.

St. John H and Philipson WR 1960 List of the flora of Oeno Atoll, Tuamotu archipelago, South-Central Pacific Ocean. *Transactions of the Royal Society of New Zealand*, **88:** 401-403.

St. John H and Philipson WR 1962 An account of the flora of Henderson Island, South Pacific Ocean. *Transactions of the Royal Society of New Zealand, Botany*, **1:** 179-194.

Uhe G 1974 Medicinal plants of Samoa. *Journal of Economic Botany*, **28:** 1-30.

Wagner WL, Herbst DR and Sohmer SH 1990 Manual of the flowering plants of Hawai'i. *B.P. Bishop Museum Bulletin*, **83.**

Waldren S, Florence J and Chepstow-Lusty AJ 1995a Rare and endemic vascular plants of the Pitcairn group, south-central Pacific Ocean: a conservation appraisal. *Biological Conservation*, **74:** 83-98.

Waldren S, Florence J and Chepstow-Lusty AJ 1995b A comparison of the vegetation communities from the islands of the Pitcairn Group. *Biological Journal of the Linnean Society*, **56:** 121-141.

Weisler M, Benton TG, Brooke M de L, Jones PJ, Spencer T and Wragg G 1991 The Pitcairn Islands Scientific Expedition (1991-1992): first results, future goals. *Pacific Science Association Bulletin*, **43:** 4-8.

Weisler MI 1994 The settlement of marginal Polynesia: New evidence from Henderson Island. *Journal of Field Archaeology*, **21:** 83-102.

Weisler MI 1995 Henderson Island prehistory: colonization and extinction on a remote Polynesian island. *Biological Journal of the Linnean Society*, **56:** 377-404.

Weisler MI 1996 Taking the mystery out of the Polynesian 'mystery islands': A case study from Mangareva and the Pitcairn group. In: Davidson JM, Irwin G, Leach BF, Pawley A and Brown D, eds, *Oceanic Culture History: Essays in Honour or Roger Green*, pp.615-629. New Zealand Journal of Archaeology Special Publication: Dunedin, New Zealand.

Weisler MI 1997 Prehistoric long-distance interaction at the margins of Oceania. In: Weisler MI, ed, *Prehistoric Long-distance Interaction in Oceania: An Interdisciplinary Approach.*, pp.149-172. New Zealand Archaeological Association Monograph 21.

Weisler MI 1998 Issues in the colonization and settlement of Polynesian islands. In: Vargas Casanova P, ed., *Proceedings of the Second International Congress on Easter Island and East Polynesian Prehistory,* pp. 79-94. Easter Island Studies Institute, FAU, University of Chile: Santiago.

Weisler MI and Gargett RH 1993 Pacific island avian extinctions: the taphonomy of human predation. *Archaeology in Oceania*, **28:** 85-93.

Whistler WA 1984 Annotated list of Samoan plant names. *Journal of Economic Botany*, **38:** 464-489.

Whistler WA 1991a The ethnobotany of Tonga: the plants, their Tongan names, and their uses. *Bishop Museum Bulletin in Botany*, **2:** 1-155.

Whistler WA 1991b Polynesian plant introductions. In: Cox PA and Banack SA, eds, *Islands, Plant and Polynesians, An Introduction to Polynesian Ethnobotany*, pp. 41-66. Dioscorides Press: Portland, Oregon.

Whistler WA 1992 *Flowers of the Pacific Island Seashore*, 154 pp. Isle Botanica: Honolulu.

Wragg GM 1995 The fossil birds of Henderson Island, Pitcairn Group: natural turnover and human impact, a synopsis. *Biological Journal of the Linnean Society*, **56:** 405-414.

Wragg GM and Weisler MI 1994 Extinctions and new records of birds from Henderson island, Pitcairn group, South Pacific Ocean. *Notornis*, **41:** 61-70.

Zizka G 1991 *The flowering plants of Easter Island,* 108 pp. Palmengarten: Frankfurt, Germany.

Table 1. Summary of plant introductions to Henderson island

Taxon	*Likely Origin*	*Dispersal*
Achyranthes aspera var. *pubescens*	passive Polynesian introduction or native	Adherence
Aleurites moluccana	deliberate Polynesian/Pitcairn introduction	?
Barringtonia asiatica	Polynesian timber import?	Seawater
Cocos nucifera	deliberate Polynesian/Pitcairn introduction	Seawater
Cordia subcordata	(native?)/deliberate Polynesian introduction	Seawater
Cordyline fruticosa	deliberate Polynesian introduction	?
Cyrtosperma chamissonis	deliberate Polynesian introduction	?
Hedyotis romanzoffiensis	accidental expedition introduction	Flotation or ingestion
Hernandia sp.	native; Polynesian timber import?	Avian ingestion?
Hibiscus tiliaceus	Polynesian timber import? Native?	Flotation?
Lycopersicon esculentum	deliberate Pitcairn introduction	?
Musa sp.	deliberate Polynesian and Pitcairn introduction	?
Pandanus tectorius	native/deliberate Polynesian introduction	Flotation
Passiflora maliformis	recent adventive/deliberate Pitcairn introduction	?
Solanum americanum	recent adventive	Avian ingestion?
Setaria verticillata	recent adventive	Adherence
Thespesia populnea	native/deliberate Polynesian introduction	Flotation
Thuarea involuta	native/Polynesian weed	Flotation or adherence?

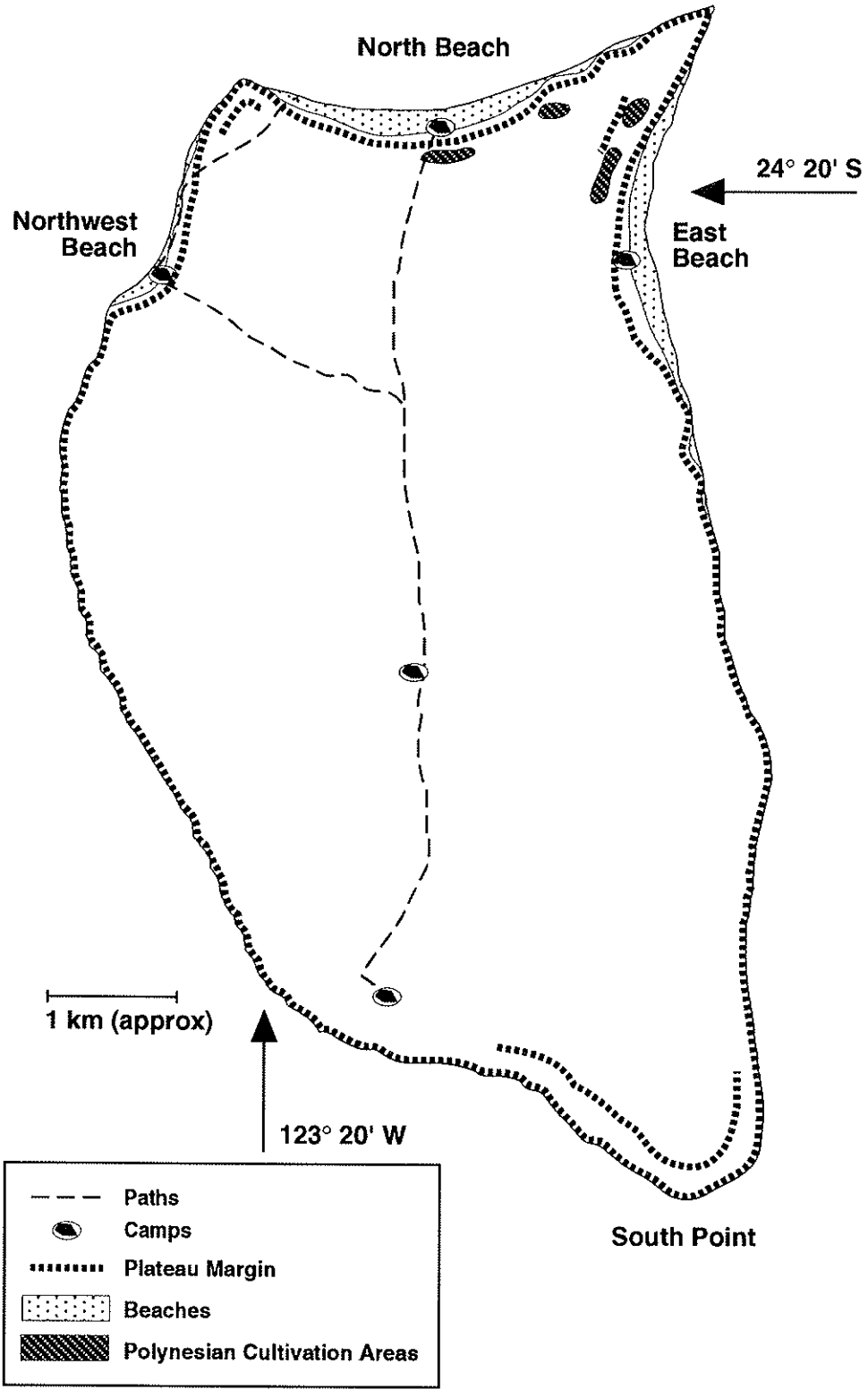

Figure 1. Henderson island, south-central Pacific Ocean, showing places named in text, plateau margin, beaches and areas of Polynesian cultivation.

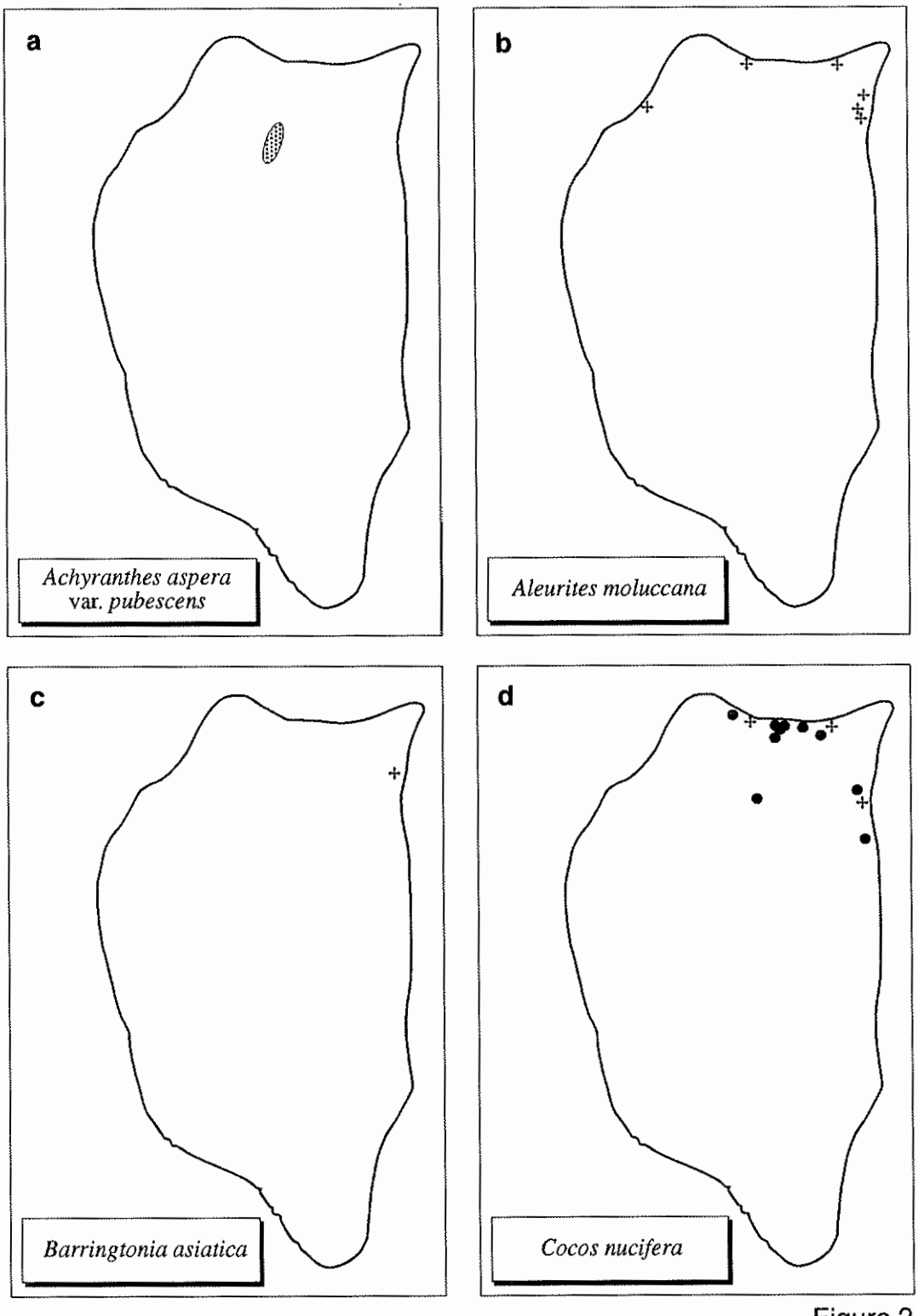

Figure 2

Figure 2. Distribution of potentially non-native plant taxa on Henderson. All fossil plant finds (✢), isolated extant individuals or small groups (●) and more continuous distributions (shading) are recorded.

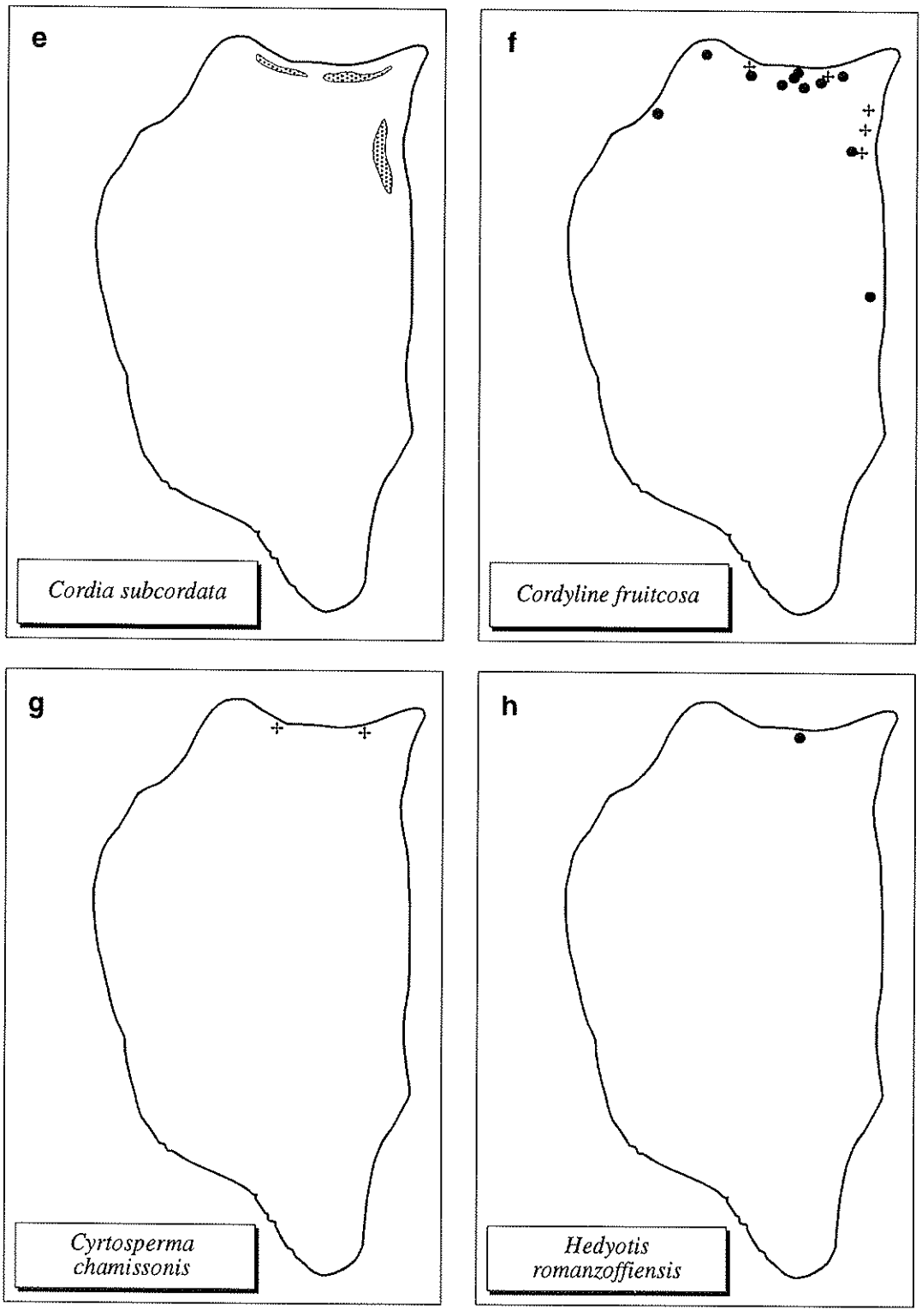
e
Cordia subcordata
f
Cordyline fruitcosa
g
Cyrtosperma chamissonis
h
Hedyotis romanzoffiensis

Figure 2

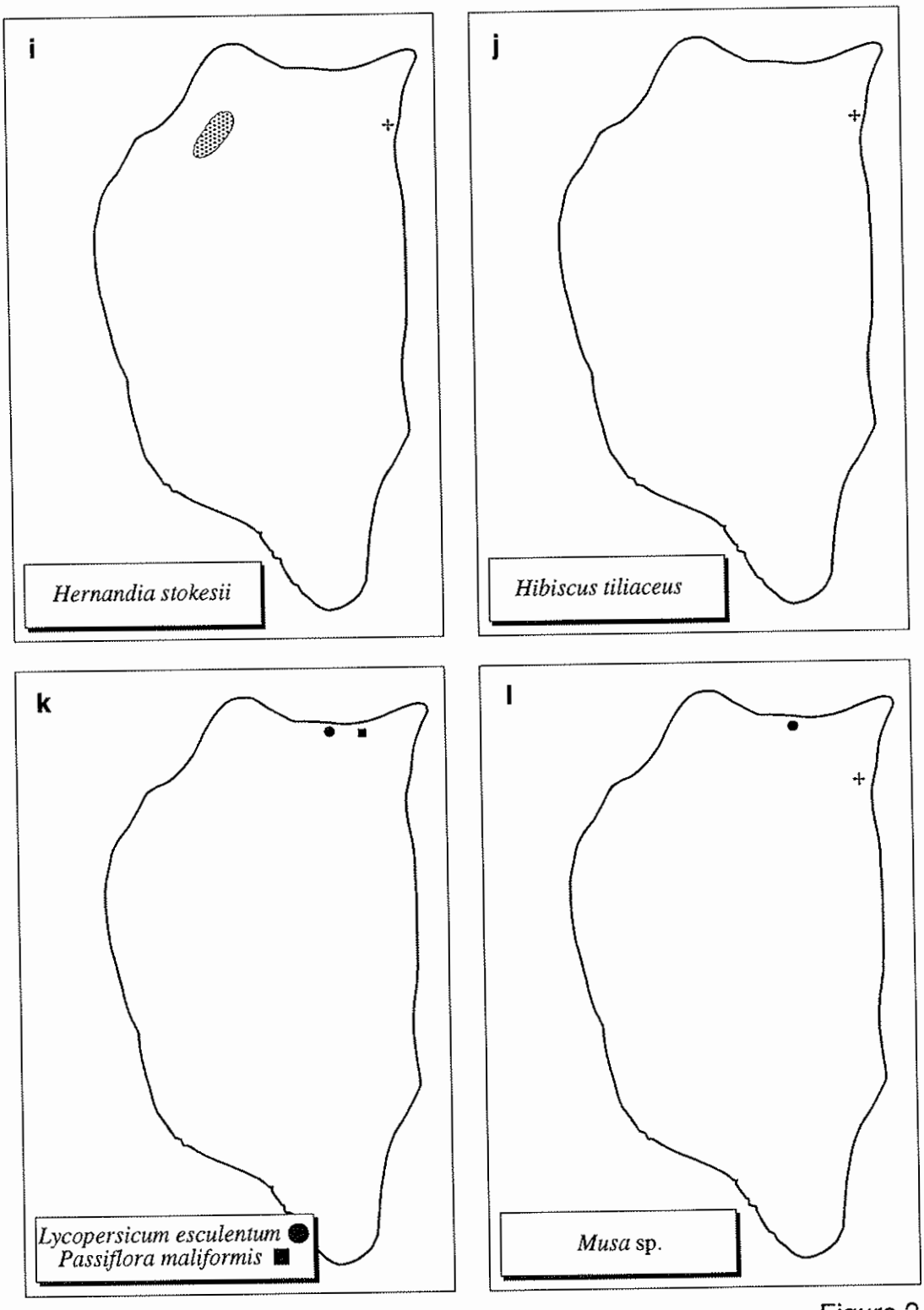
i
Hernandia stokesii
j
Hibiscus tiliaceus
k
Lycopersicum esculentum
Passiflora maliformis
l
Musa sp.

Figure 2

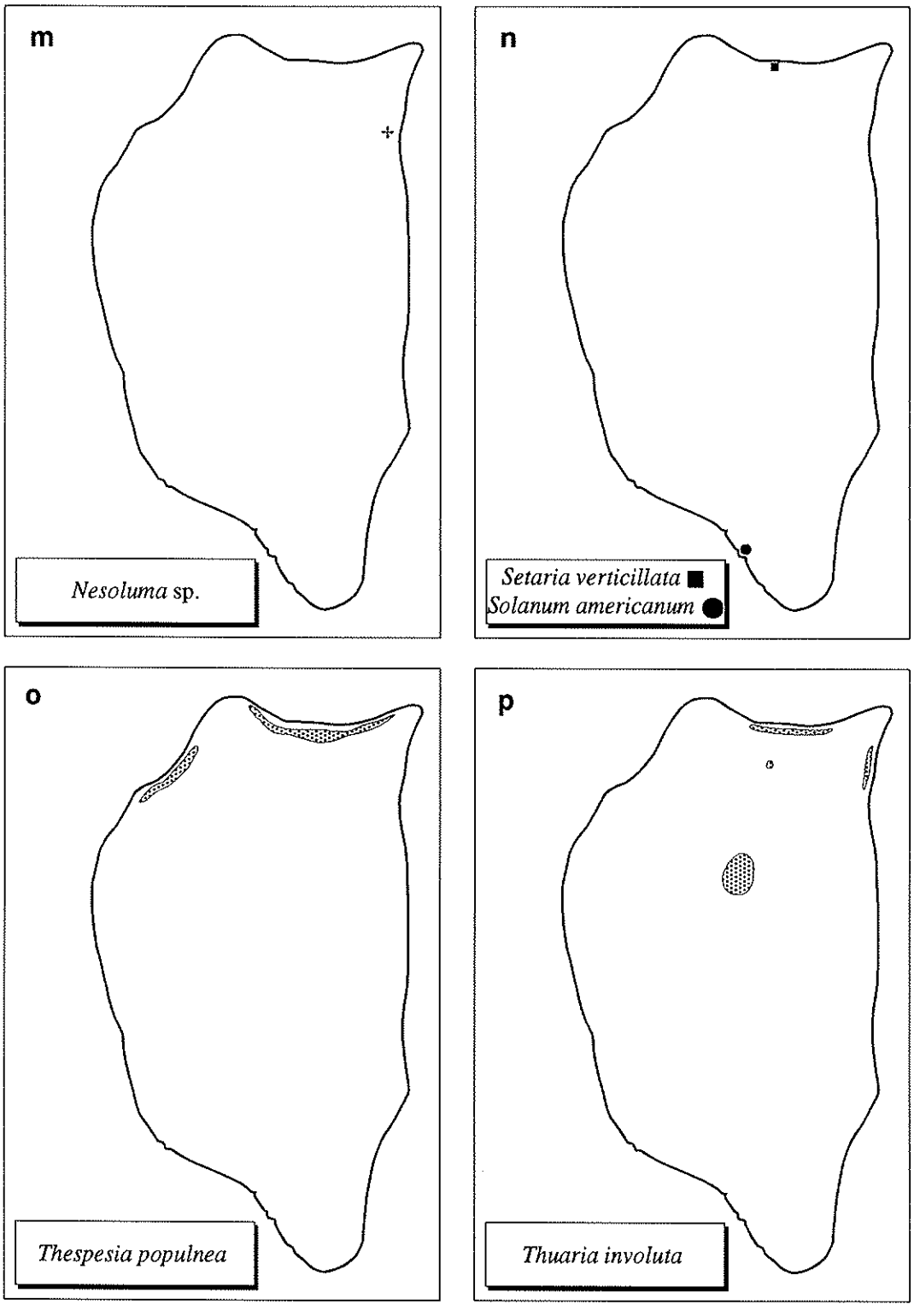
m
Nesoluma sp.
n
Setaria verticillata
Solanum americanum
o
Thespesia populnea
p
Thuaria involuta

Figure 2