Stranded Tropical Seeds and Fruits on the Coast of the Japanese Mainland

HIROKI NAKANISHI

Institute of Biology, Faculty of Liberal Arts, Nagasaki University, Nagasaki 852, Japan

Abstract. Seeds and fruits of tropical plants capable of floating in sea water are carried by the Kuroshio Current from southeastern Asia and Micronesia to the Japanese archipelago. Twenty-eight species of disseminules washed ashore on beaches of the Japanese mainland are described, and fourteen are illustrated. The western coast of the Japan Sea usually receives drift disseminules because surface currents are created by northerly or northwesterly prevailing winds.

Introduction

Descriptions of tropical seeds and fruits stranded on beaches of Europe were first documented in the seventeenth century. Few records were published in the eighteenth and nineteenth centuries. Most records noted that disseminules of tropical plants had been carried to the coasts of eastern Europe and the southwestern U.S. by the Gulf Stream. The major contributions to information on stranded disseminules in the twentieth century were first made by Guppy (1917), Colgan (1919) and Muir (1937). Detailed works were recently done by Gunn (1968), Gunn and Dennis (1972a, 1972b, 1973, 1976) and Nelson (1978).

The Japanese archipelago is swept by warm ocean currents which bring tropical drift. These drift products include fruits and seeds of tropical plants. Descriptions of these disseminules have been sparse compared to Europe and North America. Early descriptions of these disseminules were done in Honzo-sho, classical books of natural history, i.e. Endo (1681), Kaibara (1715) and Ono (1803). Until recently, there were no publications of drift disseminules, except for articles in local newspapers. Scientific records may be found in short reports of Kitami (1955), Satomi (1956) and Ikegami (1956). Later authors described the drift records in various districts (Kiyosue 1966, Kitami 1970, Ishii 1973, 1976, Ikezaki 1974, 1978, Nakanishi 1968, 1979, 1981, 1983a and Tsuruoka 1981). Most of these reports described only the name of the species and the localities. Mr. Ishii, an excellent collector, presented information concerning folklore, identification and observation of stranded disseminules in northern Kyushu (Ishii 1973, 1976). Only Nakanishi (1981, 1983b) has treated drift disseminules from the entire Japanese coast.

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Ocean Currents

Drift seeds and fruits float on sea water, and their voyages are determined by the direction of surface currents. The main surface currents in the Northern Hemisphere, the North Pacific and the North Atlantic, circulate in a clockwise direction, influenced by

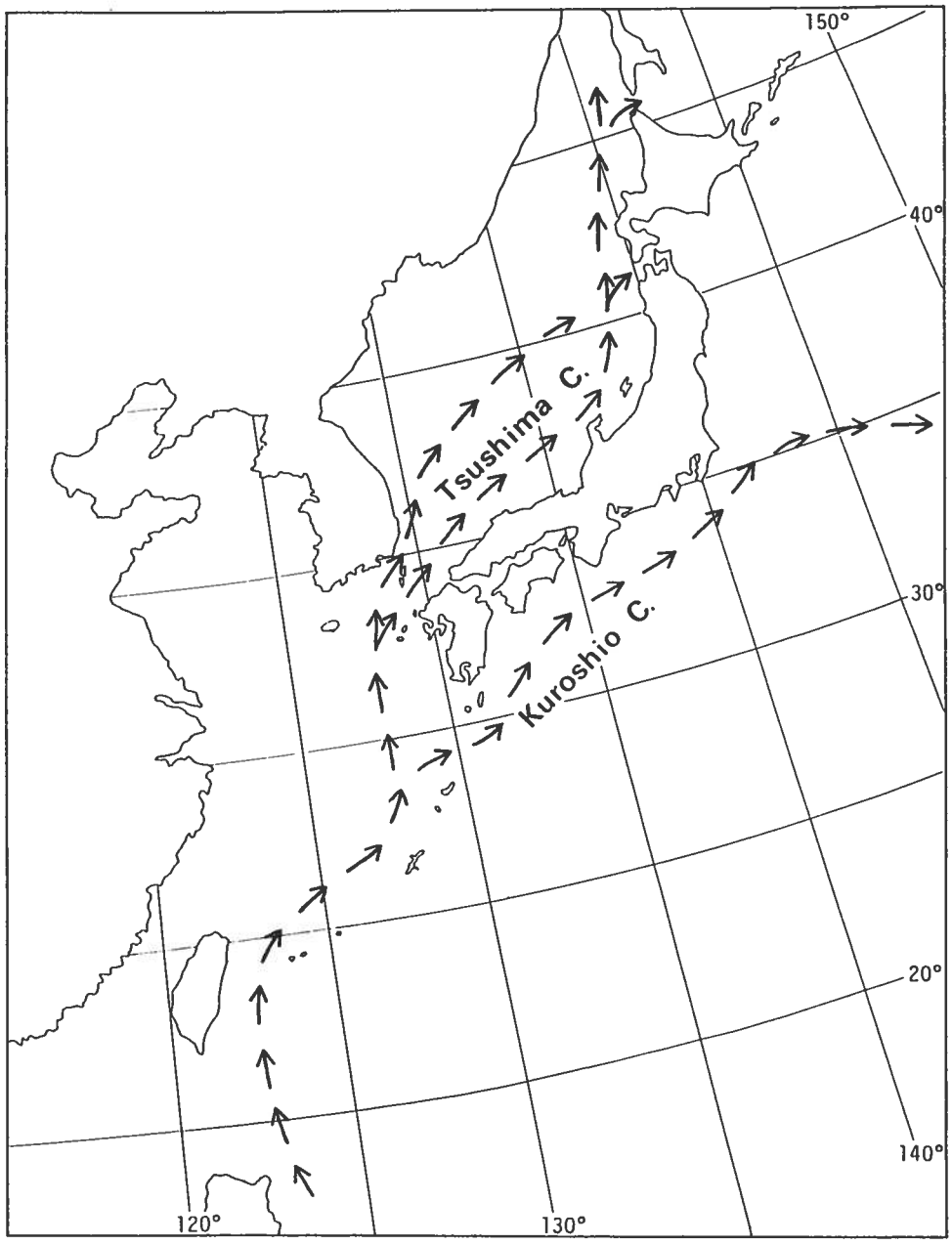

Fig. 1. Map showing the Kuroshio Current in the northwest Pacific.

trade winds and westerlies. The surface water of the Pacific North Equatorial Current flows in a westerly direction from the New to the Old World. The current turns northwards east of the Philippines and forms the Kuroshio or Japan Current, which flows east of Taiwan into the East China Sea (Fig. 1.). It flows north of the Ryukyu Islands and reenters the Pacific Ocean. The current then divides, with a branch entering the Japan Sea (Tsushima Current) and the main body flowing south of Kyushu, Shikoku and central Honshu. Beyond the Boso Peninsula of central Japan, the surface water is diverted eastwards and forms the North Pacific Current, which flows across the northern Pacific and joins the California current.

The Tsushima Current, a powerful branch of the Kuroshio Current, flows northwards west of Kyushu, then turns northwest passing through the Korean Straits and the Tsushima Straits between the Korean Peninsula and Kyushu. It continues a northwest course through the Japan Sea.

Thus any floating object can be transported from the tropical Pacific Islands and southeastern Asia to the Japanese archipelago.

Drift Seeds and Fruits

Disseminules of twenty-eight species have been identified from collections made by me between 1978 and 1985. In the following section, each disseminule is described and fourteen are illustrated. Recovery sites based on my records and past literatures are shown in Figs. 2–5.

1. *Aleurites fordii* Hemsley (Euphorbiaceae)

Jap. name: Shina-aburagiri

Fruit subglobose, pointed at tip, 3 to 5 cm in diameter, containing 3 to 5 seeds. Seeds ellipsoidal, three ridges, 2 to 2.5 cm long, 1.5 to 2 cm wide, rugged surface, dark brown. This is a wood oil tree cultivated in tropical to warm-temperate regions. The seeds of this species are common, but the fruits rarely drift to southern and central Japan (Fig. 2.). Stranded fruits are usually cracked and most seeds seem to be nonviable.

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

Jap. name: Kukuinoki

Seed subglobose, pointed at base, 2.5 to 3.5 cm in diameter, rugged surface, black or grayish brown. The candle nut tree is widely cultivated in the tropics because its seeds are a source of oil. The stranded seeds are rare in northern Kyushu, but occasionally found in the Ryukyu Islands. The drift seeds usually bear marine algae and bryozoa, seeds are usually nonviable. It is improbable that the distribution of the species can be attributed to ocean currents.

3. *Areca catechu* L. (Palmae)

Jap. name: Binroujyu

Only one seed of this species was found on the coast of Yamaguchi Prefecture, western Honshu. The seed is brown, subglobose, about 2.5 cm in diameter. Drift seeds are

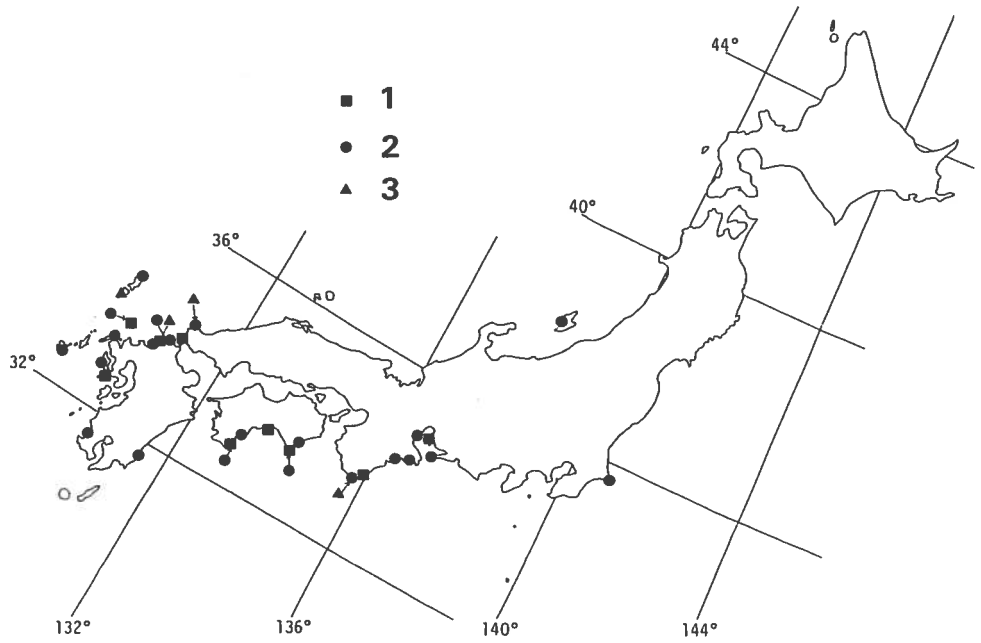

Fig. 2. Recovery sites of tropical drift fruits and seeds. 1: *Aleurites fordii;* 2: *Barringtonia asiatica;* 3: *Calophyllum inophyllum.*

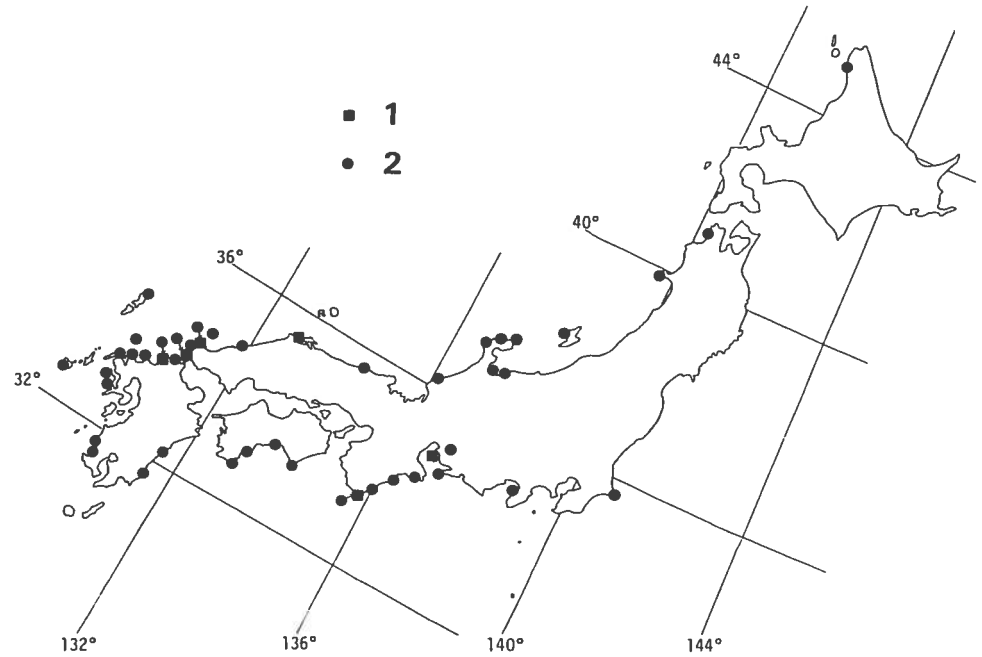

Fig. 3. Recovery sites of tropical drift fruits and seeds. 1. *Cerbera manghas;* 2: *Cocos nucifera.*

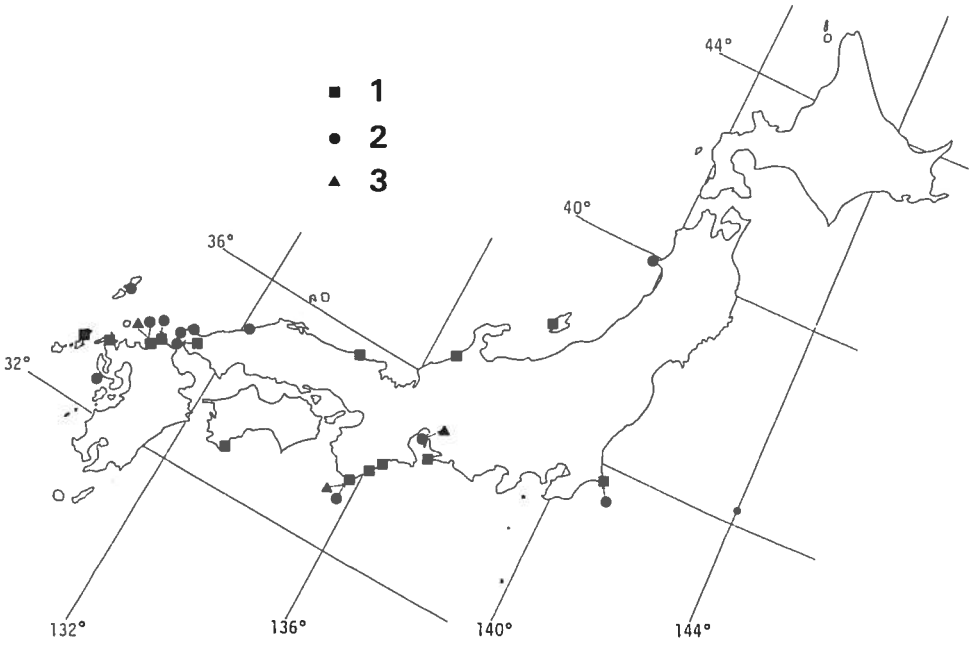

Fig. 4. Recovery sites of tropical drift fruits and seeds. 1: *Entada* spp.; 2: *Heritiera littoralis;* 3: *Hevea brasiliensis.*

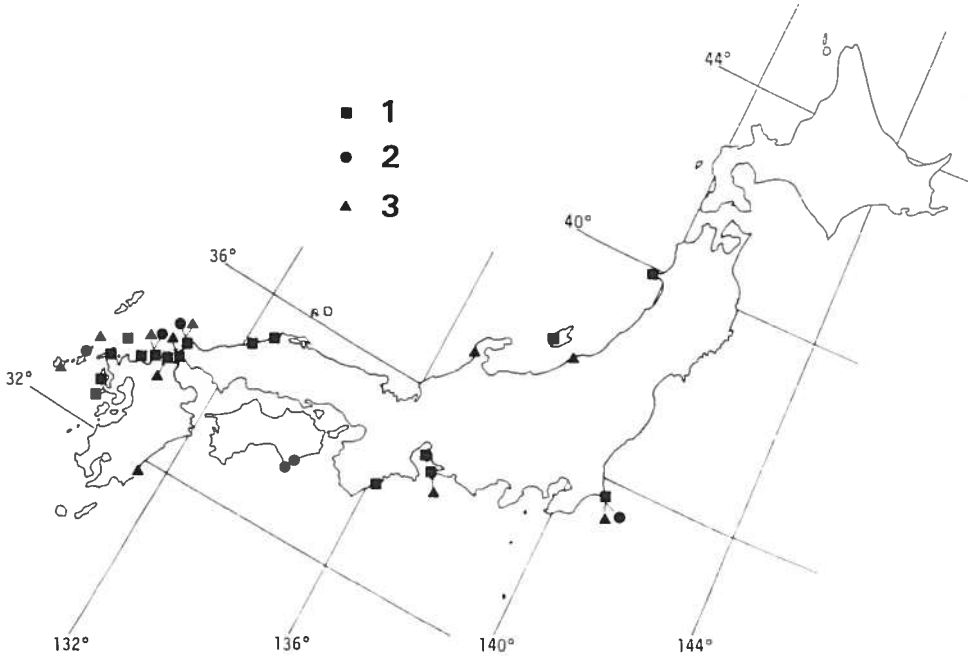

Fig. 5. Recovery sites of tropical drift fruits and seeds. 1. *Nypa fruticans;* 2: *Terminalia catappa;* 3: *Xylocarpus granatum.*

reported from Thailand (Kerr 1930). This species is not a coastal plant, and drift seeds may be discarded from ships.

4. *Barringtonia asiatica* (L.) Kurz. (Lecythidaceae)

Jap. name: Gobannoashi

Fruit grayish brown, depressed turbinate, four-ridged, almost square in cross section, about 10 cm long, two large persistent sepals at the apex, fibrous pericarp, and containing one seed. This species is often a dominant tree in the littoral forest ranging from Madagascar to southeastern Polynesia and Australia. Within its range, stranded fruits are common. Muir (1937) recorded drift fruits on beaches of South Africa, but it has not become established there. Drift fruits may lack sepals and may be decomposed. On central and southern Japanese beaches, drift fruits have been known for about 200 years (Fig. 2.). Fruits with viable seeds are unknown.

5. *Barringtonia racemosa* (L.) Bl. ex DC. (Lecythidaceae)

Jap. name: Sagaribana

Fruit ovoid, quadrangular, 5 to 9 cm long, crowned by persistent calyx. This small tree grows on seashores and tidal river banks, but not along sandy beaches. Fruits are rarely cast ashore in the Japanese mainland and are more frequently stranded in the Ryukyu Island where the species grows. Drift fruits vary in size. Larger fruits are considered to have been transported from tropical areas, and not from the Ryukyu Islands. The exocarp of drift fruits is decomposed and the fibrous mesocarp exposed. These fruits seem to decompose more easily than those of *B. asiatica* in the marine environment.

6. *Calophyllum inophyllum* L. (Guttiferae)

Jap. name: Terihaboku (Yarabo)

Fruit globose, 2.5 to 4 cm in diameter, drupaceous with a thin epicarp. This species grows along the beaches of the Ryukyu Islands and is frequently planted inland as an ornamental. Drift fruits rarely are found in southern and central Japan (Fig. 2), but are common in the Ryukyu Islands. The epicarp is quickly decomposed and only fragments remain around the tip of the fruit. The exposed hard mesocarp is grayish white or white-brown and smooth to slightly roughened.

Ohsawa (1977) reported that besides *Ipomoea pes-caprae* the fruits of *C. inophyllum* were stranded on the newly formed volcanic island, Nishinoshima-shinto, situated south of Ogasawara.

7. *Carya illinoensis* (Wang.) K. Koch. (Juglandaceae)

Jap. name: Pekan

Only one endocarp has been found along the coast of Nagasaki Prefecture, western Kyushu. It is ellipsoidal, 3.3 cm long, 2 cm in diameter, light brown with smooth surface. Drift fruits are known from Florida (Gunn 1968).

8. *Casuarina litorea* L. (Casuarinaceae)

Jap. name: Mokumao

Only one cone has been found in the drift on the beach of Aichi Prefecture, central

Japan. Cones are frequently cast ashore in the Ryukyu Islands where the plants are often planted along the beaches.

9. *Cerbera lactaria* Ham. (Apocynaceae)
Jap. name: Mifukuragi (Okinawa-kyochikuto)
Fruit ellipsoidal, 4.5 to 7 cm long and 3.5 to 4.5 cm wide, fibrous mesocarp, containing one seed. Drift fruits are common in the Ryukyu Islands where the plant often grows on seashores (Nakanishi 1983a), but are rare on the Japanese mainland. The exocarp of the drift fruit is decomposed and the fibrous corky mesocarp is exposed. Occasionally only one-half of the two-segmented fruit drifts ashore.

10. *Cerbera manghas* L. (Apocynaceae)
Jap. name: Ohmifukuragi
Fruit globose or subglobose, 6 to 10 cm in diameter, fibrous mesocarp, containing one seed. This species can be distinguished from the preceding species by shape and size of fruits. Fibers of the mesocarp of *C. manghas* are thicker than *C. lactaria*. Drift fruits, mostly broken, are rare on southern and central Japanese beaches (Fig. 3.).

11. *Cocous nucifera* L. (Palmae)
Jap. name: Kokoyashi
Fruit brown, subglobose or ellipsoidal, 20 to 30 cm long, 15 to 20 cm broad, fibrous mesocarp, bony endocarp with three depressions or pores. The coconut, the most famous drift fruit, has been reported from many places in warm temperate regions of the world. Some workers (e.g. Dennis & Gunn 1971) believe that some coconuts on those beaches have been washed into the sea from local urban refuse dumps and may not have been carried by ocean currents. Drift coconuts may also be thrown or washed overboard from ships. Imported coconuts sold in local fruitshops and it is possible that the coconuts were left on beaches as garbage. Commercial coconuts are usually uniform in both size and shape, but stranded coconuts vary from large to small and ellipsoidal to globose. These fruits occasionally have their exocarp decomposed with the fibrous mesocarp exposed and may also have barnacles or echinoderms attached to them. It is suggested that most of the stranded Japanese coconuts have been drifting in the ocean for many months on their way from southeastern Asia. I found a hemp sack stamped Singapore containing one coconut cast on the coast in central Japan. In Japan, drift coconuts have been known for some hundred years. Ono (1803) recorded some regions where coconuts drifted to central and southern Japanese beaches.

12. *Combretum tetralophum* C. B. Clarke (Combretaceae)
Jap. name: Yotsubanekazura
Only one fruit of this species was found cast ashore on the beach of Yamaguchi Prefecture, western Japan. The fruit is ovate with apex prolonged, four-ridged, almost square in cross section, 5 cm long, 1.8 cm in width.

13. *Cycas revoluta* L. (Cycadaceae)
Jap. name: Sotetsu

Seed ovoid, slightly compressed, 3.5 to 4.5 cm long, 2.5 to 3 cm in width, reddish brown; drift seed grayish. This species grows in coastal areas of southern Kyushu and the Ryukyu Islands where the seeds are commonly cast ashore. Except for these distribution areas, the drift seeds are rarely found. The species is often planted in central and southern Japan so that some of the drift seeds may have originated from local refuse dumps.

14. *Elaeris guineensis* Jacq. (Palmae)

Jap. name: Aburayashi

An endocarp of the oil palm was found in drift on the beach of Yamaguchi Prefecture, western Japan. The endocarp is subellipsoidal, dark gray, 29 mm wide and 20 mm at the narrow part, surface bearing numerous parallel striations.

15. *Entada parvifolia* Merr. (Leguminosae)

Jap. name: Himemodama

Seed shiny, brownish black, hard, globose or ellipsoid, apiculate in center of both surfaces, 3.5 to 5 cm in diameter, about 1.5 cm thick. In Japan drift seeds of *Entada* have been known from the beginning of the nineteenth century, and they are believed to be from one species. However, the drift seeds can be divided into two groups by the differences in shape and color. In the sense of Kanehira (1936), these seeds can be identified as *E. parvifolia* and *E. phaseoloides*. The drift seeds of *E. parvifolia* rarely are found, except in the Ryukyu Islands where the plant grows.

16. *Entada phaseoloides* (L.) Merr. (Leguminosae)

Jap. name: Modama

Seed shining, dark maroon-brown, hard, flattened globose, 4 to 6 cm diameter, 2 to 3 cm thick. This species is a large woody climber commonly found in broad-leaved forests of the tropics and occasionally subtropics. Seeds of *Entada* species are one of the best known drift disseminules in the world because of their conspicuous large, shiny beans. Seeds have been used for ornaments such as lockets, snuff boxes and other keepsakes. In Japan, this seed is the best known tropical drift seed other than coconuts. Drift seeds are more frequent than the previous species. The seeds, washed ashore with seaweeds, were often found by beach combers. Lay people might mistakingly believe them to be seeds of seaweed.

17. *Garcinia mangostana* L. (Guttiferae)

Jap. name: Mangosuchin

Fruit globose or spheroidal, 5 to 7 cm in diameter, reddish purple, tough pericarp, white pulp, trace of stigma on top of fruit. The mangosteen is widely cultivated in the tropics of Asia and is famous for its edible fruit often described as the best fruit in the world. Numerous fruits tied together by a string have been found on beaches. This indicates that they were discarded by humans. The fruits are usually washed ashore with their woody brown pericarp intact. Beside this species, the edible fruits which wash ashore on Japanese coasts are *Carica papaya* L., *Mangifera indica* L., *Durio zibethinus* L. and *Artocarpus heterophyllus* Lam. They may be fruits thrown or washed overboard from ships. These orchard species are not coastal plants.

18. *Heritiera littoralis* Dryand. (Sterculiaceae)

Jap. name: Sakishima-suonoki

Fruit oblong, 3 to 5 cm long, with a strong sharp keel, indehiscent, woody, purple brown. This is a large evergreen tree scattered or clumped along sea shores. Drift fruits are comparatively common in the Ryukyu Island where the plant grows, and are widely found also on coasts in the Japanese mainland. Besides the fibrous corky mesocarp, the space around the seed adds buoyancy. However, the pericarp at the keel decomposes readily and the seed is usually decayed. The plant does not seem to achieve long distance dispersal by ocean currents.

19. *Hevea brasiliensis* Muell. Arg. (Euphorbiaceae)

Jap. name: Paragomunoki

Seed ellipsoidal with a prominent groove on the face, 2.3 to 2.5 cm long, 1.8 to 2.2 cm in width. The drift disseminules are usually seeds and rarely known in southern and central Japan. Only one fruit containing three seeds was found on the beach of the southern Kii Peninsula.

20. *Inocarpus edulis* Forst. (Leguminosae)

Jap. name: Taiheiyo-kurumi

Pod 5 to 6 cm long, 4 to 5 cm width, thick, uneven, indehiscent, containing one seed. Drift fruits were found only on the coasts of Aichi and Fukuoka Prefectures.

21. *Mucuna macrocarpa* Wall. (Leguminosae)

Jap. name: Irukanda (Ujirukanda)

Seed lustrous black, suborbicular, 20 to 30 mm in diameter, 8 to 10 mm in thick, strongly compressed in cross section. The hilum black, about five-sixths of the seed circumference, 3 mm in width. The drift seeds of *Mucuna* spp. are known on various beaches of the world. In the Ryukyu Islands, four species are known as the drift seeds (Nakanishi 1983a), but the seed has not been found in the Japanese mainland. Two seeds of the species were found on beaches of Nagasaki Prefecture, southwestern Japan.

22. *Nypa fruticans* Wurmb. (Palmae)

Jap. name: Nippayashi

Fruit shiny dark brown, variable in shape, usually compressed on three ridges, ovoid, 10 to 14 cm long, fibrous husk surrounding one seed. This palm is a common tree in mangrove swamps of southern Asia and occurs irregularly in Iriomote Island, southernmost of the Ryukyu Islands, which is the northern limit of this species. It does not bear normal fruit there because of cold temperatures.

The drift fruits of the species are as common as coconuts and are recorded on all the beaches of Japan except Hokkaido (Nakanishi 1981, 1982). More than one-third of the drift fruits had germinated and were dead. They may have germinated while floating in sea water, but died from the cold as they drifted north.

23. *Pandanus odoratissimus* L. f. (Pandanaceae)

Jap. name: Adan

This species grows luxuriantly along the beaches of the Ryukyu Islands. The mericarps of the species commonly drift ashore in these areas. On the Japanese mainland the drift mericarps have been reported only in northern Kyushu by Ishii (1976).

24. *Rhizohora stylosa* Griff. (Rhizohoraceae)

Jap. name: Ohbahirugi (Yaeyamahirugi)

Only one radicle, which was about 30 cm long, was washed ashore in Yamaguchi Prefecture, western Japan. The drift radicle of a Rhizophoraceae species reported by Ishii (1977) from northern Kyushu may have been this species. This mangrove plant occurs from the palaeotropics to the southern Ryukyu Islands, where the stranded radicles of the species are commonly found. Other species of Rhizophoraceae are also found in the Ryukyu Islands, but their drift radicles have never been reported on Japanese mainland beaches.

25. *Ricinus communis* L. (Euphorbiaceae)

Jap. name: Tougoma

Seed flattened ellipsoidal, 1.5 to 2 cm long, shining grayish or reddish brown with spots. The plant is cultivated from tropical to temperate regions. The seeds frequently may wash ashore on the coasts of central and southern Japan. The seedlings and young plants are occasionally found in drift lines of these beaches. The seeds have been shown to be capable of floating intact in sea water for three months (Kerr 1930).

26. *Sapium indicum* Willd. (Euphorbiaceae)

Jap. name: Ohmi-nankinhaze (Maburuhaze)

Fruit globose, 2 to 3 cm in diameter, slightly compressed. Drift fruit is grayish white, radiately cracked into six divisions. It is rarely found on the coast of Kyushu.

27. *Terminalia catappa* L. (Combretaceae)

Jap. name: Momotamana (Kobateishi)

Fruit flattened ellipsoidal, stranded fruit with decomposed outer layer, fibrous mesocarp exposed, with one almond-like seed. It is a common fruit stranded on Florida beaches (Gunn 1968). In Japan the drift fruits of this species were rarely found in southwestern Japan except in the Ryukyu Islands where the plant occurs. The stranded fruits are found in various conditions of preservation, from the fibrous inner layer revealed to only the corky endocarp remaining.

28. *Xylocarpus granatum* Koening (Meliaceae)

Jap. name: Hoganhirugi

Fruit large, globose, 10 to 20 cm in diameter, dehiscent. Seed triangular sharp, 5 to 8 cm long, brown. This plant is distributed in tropical Asia. Recently, drift mericarps are found relatively frequently on the coasts of southwestern Japan. Most of them were apparently nonviable. Some had been pierced by small borers and easily break.

Discussion

In middle latitudes the impact of warm currents is greater on the eastern side than on the western side of ocean basins. The Northeast Atlantic Current has various oceanic effects in western Europe. However, the Japanese archipelago lies to the west of the Kuroshio Current and more frequently receives tropical drift disseminules than do other temperate regions.

Disseminules of twenty-eight tropical species have been collected from the coast of the Japanese mainland. Most of the species described here are palaeotropical and few are of the pantropical type. These facts indicate that, in southwestern Asia and Micronesia where the Kuroshio Current originates, there are many species whose disseminules can float in sea water.

From the plotted recovery sites of drift disseminules (Figs. 2–6), it can be seen that they are found from the southern to the northern coasts on the Japan Sea side but not on northern coasts on the Pacific side, and that they occur most commonly on the western coasts of the Japan Sea side. Such a tendency is due to the pattern of ocean currents; the Tsushima Current flows along the coasts of the Japanese mainland toward the northern Japan Sea, but the Kuroshio flows away from the Japanese archipelago beyond the Boso Peninsula of central Japan. Driftages may be influenced not only by ocean currents but also by surface currents caused by winds. The monsoon is northerly or northwesterly prevailing from winter to early spring, especially in the Japan Sea. The surface currents caused by these winds move the driftages of the Japan Sea toward the shores of western Japan, so that these coasts are the most likely to receive the driftages. It is commonly stated that drift disseminules are found more frequently from winter to spring on these coasts.

Most of stranded tropical disseminules found may be derived from southeastern Asia and Micronesia and a few from the Ryukyu Islands. Some of the drift disseminules are viable, but they cannot become established on the coasts where they are cast ashore because of the cool climate. On the basis of disseminule remains of tropical plants, some paleontologists have concluded that Japan once had a tropical climate. However, these disseminules might have been drift instead.

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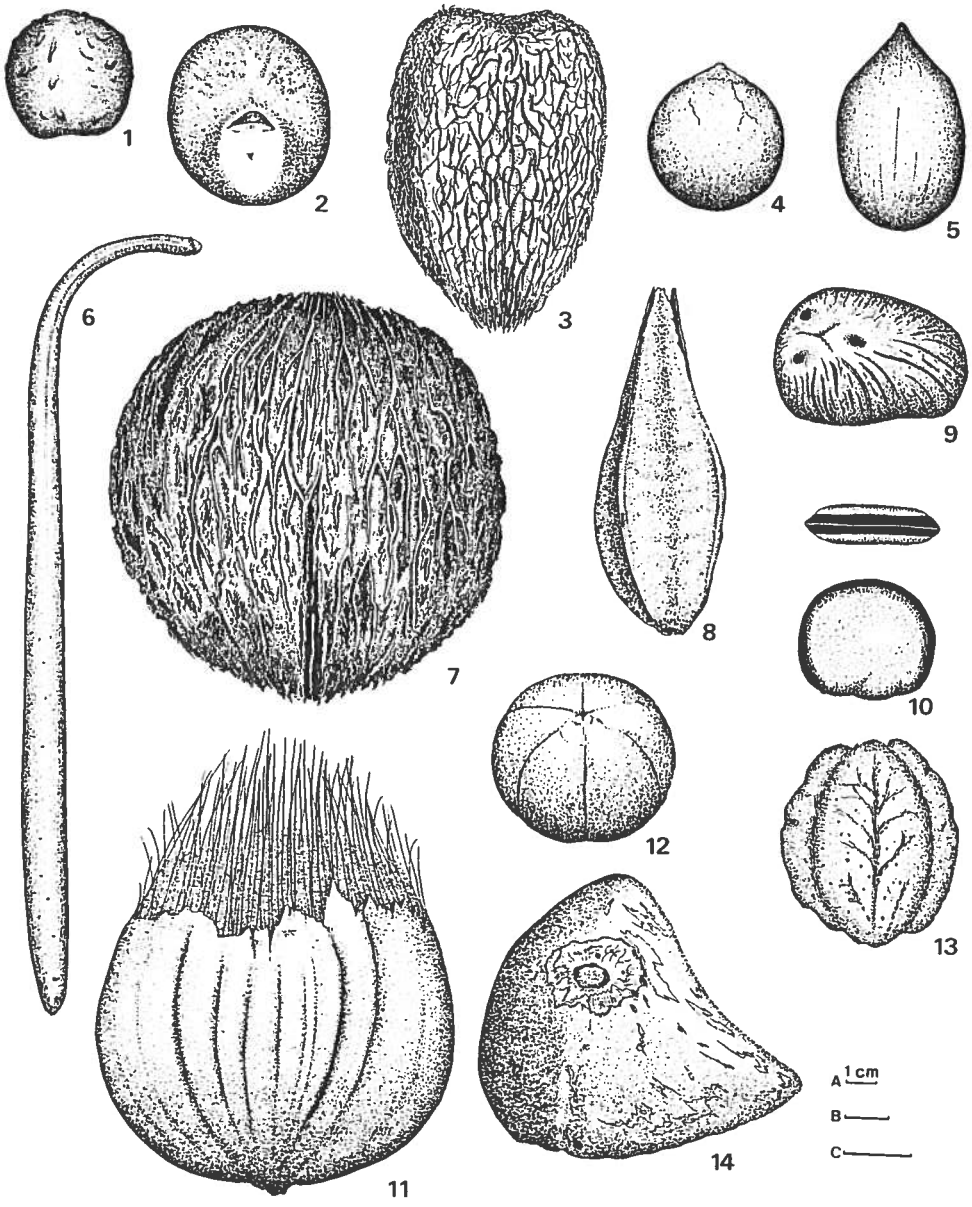

Fig. 6. Drift seeds and fruits from the coasts of the Japanese mainland. 1: *Aleurites fordii*, 2: *Areca catechu*, 3: *Barringtonia racemosa*, 4: *Calophyllum inophyllum*, 5: *Carya illinoensis*, 6: *Rhizophora stylosa*, 7: *Cerbera manghas*, 8: *Combretum tetraphum*, 9: *Elaeris guinensis*, 10: *Mucuna macrocarpa*, 11: *Nypa fruticans*, 12: *Sapium indicum*, 13: *Terminalia catappa*, 14: *Xylocarpus granatum*. (Figs. 1, 2, 5, 8, 9, 10, 12: scale C; Figs. 3, 4, 7, 13, 14: scale B; Figs. 6, 11: scale A).

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