

FRUIT AND SEEDS IN THE DRIFT ON KAW TAO.

BY A. KERR

The subject of the fruit and seeds in the drift on the beaches of Kaw Tao was alluded to in a previous paper in this Supplement, but was not then gone into in any detail. On the occasion of a fourth visit to the island, in September 1928, the opportunity was taken to make a closer examination of the drift. Most of this examination was carried out on West Beach, which is by far the most extensive beach on the island, and carries the largest amount of drift. Though the fruit and seeds of a considerable number of plants were found, a prolonged search on this and other beaches would, no doubt, have extended the list, particularly in the case of the smaller seeds.

The drift on West Beach is considerable, consisting very largely of the culms and rhizomes of bamboos, and, to a lesser extent, of branches, roots and portions of trunks of trees. Mixed with this bulky material are to be found the fruit and seeds. The bamboo must all have come from elsewhere, as no bamboos are known to grow on the island. The greater part of this drift probably comes from the mainland to the south-west of the island, that is to say from the region of Bandawn Bay. The reasons for making this statement are that the strongest winds are known to blow from the south-west, and that most of the drift is found towards the northern end of West Beach; the southern end, which is protected by a rocky point jutting out westwards, being comparatively free from it.

It may be mentioned now that the seeds of only two species of plants were found germinating in the drift; these were *Ipomoea pes-caprae* and *Nypa fruticans*. Many of the seeds and fruit bore evidence of a long period of flotation, in the shape of incrustations of barnacles and other marine organisms. Others, again, were quite clean. No doubt some of the latter may have been derived from plants growing along the beach of the island itself.

When, after their voyage over the sea, seeds do reach the beach, they are not yet in safety, as they are liable to be attacked by crabs, shore insects and rats, all of which were seen foraging in the drift, and many seeds were found more or less eaten by them. The hard covering of most of the typical floating seeds defies, however, the

attacks of such foes.

For convenience in discussing the following list of the fruit and seeds found, the species considered are divided into three categories: (a) Littoral, (b) Estuarine and (c) Inland. That is to say, under (a) are grouped species habitually growing on the sea-beach, or its immediate vicinity, (b) those growing along muddy tidal estuaries, (c) those usually found inland. Some species grow both on the littoral and in tidal estuaries, but are usually much commoner in one or the other of the two habitats. Such species have been put under the heading of their commoner habitat. Seeds have been classed as 'sound' or 'unsound' on their naked-eye appearance. It is quite probable that some of those classed as 'sound' may not have been in a viable condition. Those put down as 'unsound' were undoubtedly dead. In some cases fruit without seeds were found; these have been included in the list but classed as 'unsound.'

It was also attempted to make as exhaustive a collection as possible of the flowering plants growing on the island, a list of which it is proposed to publish later. No doubt a number of species were missed and some of these missed species may be among those whose seeds were found in the drift, but the plants noted as not occurring on the island. Such species, however, are not likely to be in sufficient numbers to affect the conclusions to be drawn from the list.

LIST OF FRUIT AND SEED FOUND IN THE DRIFT.

(a) *Littoral species*:

1. *Calophyllum inophyllum* Linn.

These fruit were common in the drift, and with sound seeds. The tree is abundant along the shores of the island, in the littoral woodland.

2. *Heritiera littoralis* Dryand.

The fruit of this tree was common in the drift. Some were apparently sound, but others were bored, and their insides gone. Many of these fruit, judging from the incrustations of barnacles, had been in the sea a long time. The tree is not uncommon in the littoral woodland of the island, and also in the mangrove forest.

3. *Canavalia maritima* Thou.

Two beans, apparently sound, were picked up in the drift. This plant grows on the beaches of the island.

4. *Sophora tomentosa* Linn.

Only one seed, apparently sound, was found. This is a common plant in the littoral woodland of the island.

5. *Caesalpinia crista* Linn (*C. bonducella* Fleming)

These seeds were not uncommon. Some showed marine incrustations, but all seen were sound. The plant is not uncommon on the shores of the island.

6. *Caesalpinia nuga* Ait.

Pods of this plant were quite common in the drift, most of them with sound seeds. This species grows on the shore of the island, but not commonly.

7. *Terminalia catappa* Linn.

These fruit were common, the seeds appearing sound. The tree grows along the shore of the island.

8. *Barringtonia asiatica* Kurz (*B. speciosa* Forst.)

Fruit of this species, containing sound seeds, were not uncommon. The tree grows along the shore of the island, with its branches often spreading far over the beach. It is probable that most of the fruit in the drift come from these trees, particularly as these fruit did not show signs of a long sea voyage.

9. *Guettarda speciosa* Linn.

These fruit were fairly numerous, and had sound seed. The tree is common in the littoral woodland of the island.

10. *Scaevola frutescens* Krause (*S. Koenigii* Vahl)

A few fruit were found, with sound seeds. The species grows plentifully along the beaches of the island.

11. *Cerbera lactaria* Ham.

One fruit was found, with sound seed. This small tree is not uncommon in the littoral woodland of the island. Its fruit can be readily distinguished from that of *C. Manghas* Linn. (*C. odollam* Gaertn.) by its smaller size.

12. *Ipomoea pes-caprae* Roth.

A few, apparently sound, seeds were picked up. These seeds

were, as might have been expected, quite smooth, showing no trace of the hairy covering of the fresh seeds of this species. The plant is abundant on the beaches of the island.

13. *Calonyction album* House

One seed, sound, only found. As it still showed traces of a hairy covering, quite possibly it came from a local plant. It is a fairly common climber on the littoral vegetation of the island.

14. *Clerodendron inerme* Gaertn.

One segment of the fruit, with no seed, was picked up. The plant is common in the littoral woodland of the island.

15. *Hernandia ovigera* Linn.

These fruit, with sound seeds, were common in the drift. Probably many came from the numerous trees of this species which grow along the beaches of the island.

16. *Casuarina equisetifolia* Linn.

The cones of this tree are common in the drift, but usually empty of their seeds; occasionally, however, one was found with sound seeds. As a rule the cones dehisce while still attached to the tree, so the normal method of distribution would be by the seeds alone. These would be hard to find in the drift, owing to their small size. Guppy reports that they have very limited powers of flotation. It is difficult to see how they are distributed, unless they float themselves or are carried on some larger floating material. *Casuarina* seems to have reached Krakatau fairly quickly. When Penzig visited the island in 1897 the species was recorded; while Ernst in 1906, 23 years after the eruption, reports casuarinas 12-15 metres in height. In places on Kaw Tao this tree forms a regular fringe along the beach, its branches overhanging the sand. It is very probable that most of the cones found fell from these trees.

17. *Cocos nucifera* Linn.

Empty husks and nuts that had been eaten by squirrels bulked largely in the drift. Whole, sound nuts were, however, not uncommon. These were gathered for eating purposes by the party. None of these nuts were seen germinating. There were one or two young coco-nut trees on the island, which were said to have been planted, and had the appearance of having been so. At one time

there must have been some mature trees, as their fallen trunks were seen. The coco-nut is only found as a cultivated plant in Siam. As elsewhere it is a littoral plant, and in Siam is chiefly cultivated along the sea-shore, it is classed as a littoral plant. Also, as the living plants on the island have been planted, it is for the purposes of this enquiry, regarded as not on the island.

18. *Thuarea involuta* R. & S.

One much worn specimen, with the characteristic shape of the fruit of this grass, was found. The seed was quite disintegrated. The grass is common on the beaches of the island.

(b) *Estuarine species*:

19. *Xylocarpus* sp.

The large seeds of *Xylocarpus obovatus* A. Juss. and of *X. moluccensis* Roem. are indistinguishable. Both seeds may have been represented in the drift, where these seeds were very plentiful. Numbers of these, judging from the marine incrustations they carried, had been floating for long periods. Some seeds were apparently sound, but many of them had been pierced by a small borer. *Xylocarpus obovatus* grows at one or two places on the shore of the island. It has been assumed that only the seeds of *X. obovatus* were present.

20. *Mucuna gigantea* DC.

Sound seeds of this species were not uncommon. It is a widespread estuarine climber, but has not been found on the island.

21. *Dalbergia candenatensis* Prain (*D. monosperma* Vahl)

The pods of this climber were abundant in the drift, the seeds appearing sound. It is a common estuarine species, but has not been seen on the island.

22. *Derris trifoliata* Lour. (*D. uliginosa* Benth.)

These pods were common in the drift, but the seeds of all those examined were soft and rather shrivelled. Attempts to germinate some of them were unsuccessful. They are, therefore, regarded as unsound. This common estuarine plant is found on the island.

23. *Bruguiera* sp.

Only one radicle was found in the drift, and it had been partly eaten by some animal and was probably not viable. Two

species of *Bruguiera* grow on the island. The genus is common in estuaries.

24. *Ceriops* sp.

A single, sound radicle of this genus was found. (*Ceriops tagal* C. B. Rob. (*C. Candolleana* Arn.) grows on the island.

25. *Cerbera manghas* Linn. (*C. odollam* Gaertn.)

One fruit was found, with sound seed. This species, common along estuaries and tidal rivers, has not been found on the island.

26. *Sapium indicum* Willd.

This was one of the commonest fruit in the drift. The seeds, while still in their stony capsule, were sound; but three seeds picked up loose were all decayed. This common estuarine tree has not been found on the island.

27. *Nypa fruticans* Wurm.

The fruit of this palm was very common in the drift. It was often to be seen germinating; but none were found with shoots more than 20 cms. high. Usually before reaching this height the shoot had dried up. These fruit were often encrusted with barnacles. No plant, beyond the seedling stage noted above, has been found on the island.

(c) *Inland species:*

28. *Dillenia indica* Linn.

Fruit of this tree were quite common, but all, including the seeds, were in a more or less rotten condition. The tree is common along rivers on the mainland. No *Dillenia* has been found on the island.

29. *Durio zibethinus* Murr.

The seeds of the durian were not uncommon in the drift, but always more or less decayed, and partially eaten by some animal. These seeds may have been thrown overboard by some passing ship. On the sand-spit of Kaw Nang Yuan, a small islet off Kaw Tao, large quantities of whole durian fruit were seen, possibly coming from the wreck of a boat loaded with them. The seeds in these were also decayed. This tree has not been found on the island. It is commonly cultivated on the mainland, and not infrequently self-sown.

30. *Neesia* sp.

The fruit of a *Neesia* was picked up, but it had dehisced, and contained no seeds. No *Neesia* has been found on the island.

31. *Grewia paniculata* Roxb.

One fruit stone, apparently of this species, was found. Its interior was quite disintegrated. This species has not been found on the island.

32. *Canarium* sp.

A single fruit-stone, belonging to some species of this genus, was picked up. The seed appeared sound. This genus is not known to occur on the island.

33. *Mangifera* sp.

One mango stone, the seed of which was rotten, was found. From its small size it probably belonged to a wild species. One species of *Mangifera* is not uncommon on the island.

34. *Spondias acuminata* Roxb.

Several stones of this tree were found in the drift, all with sound seeds. This species is found on the island. The stone of *S. acuminata* is distinctly smaller and smoother than that of *S. pinnata*, with which it might be confounded.

35. *Dioclea reflexa* Hook. f.

Three seeds of this species, all sound, were picked up. Two of them were planted later, and germinated. The plant is found on the island.

36. *Erythrina fusca* Lour. (*E. ovalifolia* Roxb.)

One bean, sound, of this tree was found. This species is common on the mainland, usually in marshy situations, but has not been discovered on the island. It is rather curious that the bean of this species should have been found, and not that of *E. indica*, which is a typical littoral tree and grows on the island.

37. *Derris elegans* Benth.?

One pod was picked up, with shrivelled seed. The identification is rather uncertain. If the pod does not belong to *D. elegans*, it belongs to a *Derris* with very similar fruit. No *Derris* with such pods has been found on the island. *D. elegans* is an inland species, usually growing along streams.

38 & 39. *Entada* spp.

The beans of what is regarded, in a wide sense, as *Entada scandens* were not uncommon. From the shape and size of the beans collected, however, it is probable that at least two species were represented. All seemed quite sound. No species of *Entada* has been found on the island.

40. *Lagerstroemia floribunda* Jack

Two capsules of this tree were picked up. The seeds showed signs of disintegration. This common inland species has not been found on the island.

41. *Lagerstroemia Flos-Reginae* Retz.

These capsules were quite common in the drift, usually still attached to branches. The seeds were all soft and friable. In all cases water seemed to have penetrated the capsule. This species is quite common along rivers on the mainland. No *Lagerstroemia* has been seen on the island.

42. *Citrullus vulgaris* Schrad.

One seed, partially disintegrated, of the water-melon was picked up. Possibly it was dropped from a ship or boat. The plant has not been found on the island. It is commonly cultivated on the mainland, and often spontaneous.

43. *Myristica* (?) sp.

Two seeds, belonging to this or an allied genus, were found. No myristicaceous tree with seeds quite this shape and size has been found on the island.

44. *Ricinus communis* Linn.

Two seeds, agreeing in shape and size with a wild form of this species, were found. Both were disintegrated internally. The species has not been found on the island. The seeds of this plant, however, have been shown by Martens to be capable of floating unharmed in sea-water for three months. It is very likely that the seeds found on Kaw Tao had been attacked by insects.

45. *Trewia nudiflora* Linn.

One fruit was found, with decayed seeds, and one loose seed, apparently sound. This species grows on the mainland along river banks, but has not been found on the island.

46 & 47. Cupuliferae.

Acorns were quite common in the drift, but usually the nut only, without its cupule. Three acorns were found, however, with the cupule still attached. These belonged to two different species, one of which may be referable to *Pasania encleisocarpa* Gamble. The other is probably also a *Pasania*, but the species is doubtful. From the shape and size of the other nuts it is probable that a third species was represented. All the nuts opened were found to be disintegrated. No member of this family has been found on the island.

48. *Dioscorea bulbifera* Linn.

One bulbil, in a rotten condition, was found in the drift. Though a bulbil does not come under the heading 'fruit and seeds', there is no doubt it serves as a means of distribution, so is included here. A bulbil of this plant, apparently sound, was picked up floating at the mouth of the Menam. The species has not been found on the island.

49. *Areca catechu* Linn.

The nut of this palm was occasionally found. One of these had apparently a sound seed, the others were rotten. Possibly these nuts came from a passing ship. The only trees on the island of this species are a few that have been planted, and are not yet in bearing. As these are known to have been planted, the species, for this inquiry, is regarded as not on the island, as in the case of the coco-nut.

50. *Zalacca* sp.

One fruit, with decayed seed, was picked up. No *Zalacca* has been found on the island.

In addition to the 50 species listed above, some 21 others, not identified, were represented among the fruit and seeds collected. Among these 21 species were one leguminous plant and one palm, the others could not be placed in their families, and none could be classed as to habitat. Only one of these species, represented by a capsule, had sound seed. All the others were more or less decayed, and many of them in a fragmentary condition.

Before tabulating the chief points about the fruit and seeds of the species listed above, a few explanatory remarks are needful.

All seeds and fruit found in the drift have been regarded as coming from elsewhere; though they may, in some cases, have been derived from plants growing along the beaches of the island, as has been noted already under the species concerned. This will not affect the result, as the doubtful species, with the exception of the *Casuarina*, are known to have fruit or seeds which can float unharmed for long periods in the sea. If but one seed of a species has been found sound, among more or less numerous unsound ones, that species has been put under the heading 'sound'.

In the following table, classifying the seeds and fruit found, each of the three categories, littoral, estuarine, and inland, has been divided into those species that are represented in the flora of the island, and those that are not. Each of these two divisions has then been subdivided into those with sound and those with unsound seeds.

TABULAR STATEMENT OF THE FRUIT AND SEEDS
FOUND IN THE DRIFT ON KAW TAO.

Littoral species	{	Species represented on the island	{ With sound seeds	15
			{ With unsound seeds	2
	{	Species not represented on the island	{ With sound seeds	1
			{ With unsound seeds	0
Estuarine species	{	Species represented on the island	{ With sound seeds	2
			{ With unsound seeds	2
	{	Species not represented on the island	{ With sound seeds	5
			{ With unsound seeds	0
Inland species	{	Species represented on the island	{ With sound seeds	2
			{ With unsound seeds	1
	{	Species not represented on the island	{ With sound seeds	7
			{ With unsound seeds	13

Unclassified	{ With sound seeds	1
	{ With unsound seeds	20
Total		<hr/> 71 <hr/>

Concerning the littoral seeds, very little comment is called for. The largest number of sound seeds was among these species, as might have been expected; for the seeds, or fruit, of most littoral plants are known to be able to float unharmed for long periods in sea-water. The two littoral species listed with unsound seeds were represented by only one seed each. One is a grass, *Thuarea involuta*, the other a common shrub, *Clerodendron inerme*. Both species are widespread on the shores of the eastern tropics, and both have hard dry fruit, unlikely to tempt birds. That of the *Clerodendron* is known to be able to germinate after floating for months in salt water. It is most probable that the fruit of the *Thuarea* is also distributed by currents.

The only fruit found of a littoral species not indigenous to the island was the coco-nut. Though none of these fruit found in the drift were germinating, it is known that drift coco-nuts do sometimes germinate, for instance the case reported on Krakatoa beach by Dr. W. Docters van Leeuwen. Mrs. Collins of Sriracha says that she has seen coco-nuts germinating on Sriracha beach; but these nuts had not been washed ashore by the sea, they had been used as supports by children learning to swim in the sea, and then abandoned on the beach. One possible reason why no germinating nuts were found on Kaw Tao, is that fishermen visiting the island collect all the sound nuts they can find for eating purposes.

Turning to the estuarine species, it is, at first glance, rather surprising that there should be so many with sound seeds which are not represented in the flora of the island. This, however, is not really to be wondered at, when it is considered that estuarine conditions are barely represented on Kaw Tao. There are no permanent streams on the island, but near the mouths of one or two of the larger seasonal streams collections of brackish water remain through the dry season. It is in these places, restricted in area, that such

estuarine plants as the island possesses grow. It is rather curious that the only two estuarine species found with unsound seeds should be species already growing on the island. The single radicle found of a *Bruguiera*, which had been partly eaten by some animal, is not of much consequence. These radicles are often found sound on beaches elsewhere, and are known to be able to germinate after long floatation in sea-water. The case of *Derris trifoliata*, however, is rather interesting, as a large number of pods were examined, and all found to have shrivelled, but not decayed seeds. A few of these shrivelled seeds were brought back to Bangkok and an attempt made to germinate them, but not one showed any signs of life. In the drift on Hua Hin beach these pods were also common; many of them showing shrivelled seeds, but in not a few cases the seeds were not shrivelled, and were beginning to germinate. This species, like most other estuarine plants, requires damp mud for its proper development. Probably if the pods had been drifted directly on to such mud, the seeds would have germinated. Instead, however, they were thrown on a hot dry sandy beach, exposed to the full sun. These conditions, no doubt, destroyed the vitality of the seed, which, unlike most other estuarine species, has a thin coat, as also has its pod. Guppy classes the seeds of this plant among those able to float for months.

It is noteworthy that *Sapium indicum*, so commonly represented by sound seed in the drift, was not found on the island. It is possible that it was overlooked, as, when not in flower or fruit, it bears a resemblance to *Excoecaria Agallocha*, a tree not uncommon on Kaw Tao.

Inland species of plants being so much more numerous than littoral and estuarine species combined, it is not surprising their fruit were so well represented in the drift, even though their facilities for reaching the sea may be fewer, and their powers of floatation less. It will be seen from the figures that very few of the inland species found in the drift are indigenous to the island. Of the two inland species found on the island and represented by sound seed in the drift, one, *Dioclea reflexa*, is a widespread plant and well known for the resistance of its seeds to the penetration of salt-water. A

sound seed of this species has even been recorded from a beach on the Shetland Islands. The *Spondias* might almost be considered a littoral plant, as it is quite common on many shores, on rocky ground not very far above the reach of the waves.

Only one unsound seed is classed as that of an inland species represented on the island, and that is of a mango; though it is not at all certain that the stone found was of the same species as the mango growing on the island. Mango stones are not uncommon in the drift on beaches elsewhere, but all that have been examined have been unsound. It is unlikely that species of this genus are distributed by currents.

There remain the fruit or seed of the 20 inland species which do not occur on the island. About two-thirds of these, 13 out of the 20, had unsound seeds. Further exploration may show that a few of these species do grow on the island. It is unlikely however that more than a few of them will prove to be indigenous, as so many are conspicuous plants, not easily overlooked.

Summing up the results, it may be said that the majority of the seeds of littoral plants found in the drift had sound seeds, and are represented in the flora of the island. The majority of the seeds of estuarine plants were also sound, but of these less than half are found growing on the island. Most of the seeds of the estuarine plants on this list are known to be viable after long periods of immersion in sea-water. The reason that more of them do not grow on the island, is that suitable conditions for their development are limited. Not only have most littoral and estuarine plants fruit or seeds that are buoyant and, for long periods, impervious to, or unharmed by salt-water; but, moreover, they have a good chance, on reaching the shore, of finding themselves in conditions suitable for their growth.

The majority of the seeds and fruit of inland plants were, on the other hand unsound; and 20 out of the 23 species are not represented in the flora of the island, as far as at present known. Of most of these inland plants it cannot be said that their absence from the flora is due to lack of suitable habitats on the island for their growth. Many of them are to be found on the mainland in

forests similar to those of the island. It may, however, be very confidently stated, as Guppy and others have pointed out, that the seeds of inland plants when drifted on to a shore, find themselves in very unsuitable conditions for their development, and, even if sound, fail to germinate, or germinate only to die off almost at once.

Among early writers on the subject, Alphonse De Candolle held the view that oceanic currents exercised extremely little influence on the diffusion of plants, and it was limited to the littoral element. In more recent times one author, Guppy, goes so far as to describe the buoyancy of fruit or seeds of inland plants as 'useless buoyancy'. There are, it is true, a number of inland plants whose seed, or fruit are buoyant and can withstand immersion in salt water for long periods, but even so it is probably rare for currents to act as a means of dispersal in such cases.

The views quoted above are, to a certain extent, supported by the present investigation. It is, however, likely that when high tides combined with storms occur, sound seeds of inland plants may be sometimes carried to habitats suitable for their development. In the new flora of Krakatoa are found a small number of inland plants whose presence it is difficult to account for except through the agency of oceanic currents.

At least two inland plants of Kaw Tao, *Dioclea reflexa* and *Spondias acuminata*, may have reached the island by way of the sea. The great majority of the inland plants cannot, however, have reached the island in this way; so their presence there must be accounted for in other ways, which it is proposed to discuss at another time.

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