SUCCESSION OF INFESTATION IN ILLIPE NUTS IN SARAWAK
AN EXAMPLE OF A CASH CROP PROBLEM*

MELVILLE CONNELL
Australian Wheat Board
G.P.O. Box 4562 Melbourne
AUSTRALIA

ABSTRACT: The oilseed known as illipe nut is a forest product, its fruits are collected by subsistence rice growers many of whom practice shifting agriculture. To these people, an illipe nut crop, requiring only labour input for an early and occasionally bountiful cash return, is an event of some considerable importance.

The commodity is interesting because of its sporadic availability in marketable quantities and the insect fauna which it attracts. Insect pest damage the nuts and expose them to infection by microorganisms which cause adverse increase in the free fatty acid content.

Poor communication between the end users and the collectors, perennial uncertainty of any marketable crop availability, complex trading arrangements, and difficulty in reaching and advising the collectors are the main factors which inhibit improvement of hygeiene and quality of illipe nut parcels at their point of entry into international trade.

INTRODUCTION: The Borneo illipe nut is an unusual, almost rare, commodity. Because of the properties of the fat which it contains, this oilseed is of interest to specialist extractors and refiners of vegetable oils and commands a high export price.

An illipe nut crop is an important event to the people who live in the interior of Sarawak: it is a windfall which gives an early and occasionally bountiful cash return. The significance of this to a jungle dwelling community which supports itself by subsistence agriculture is obvious.

Although the commodity is classified as a quality raw material, substantial degradation occurs while it is being stored and transported; its value is reduced to a very considerable extent. The succession of insect species which infest illipe nuts and the somewhat associated problem of infection by microorganisms jointly promote chemical degradation of the fat content.

THE COMMODITY: This paper is solely concerned with illipe nuts derived from the fruits of various species of *Shorea* (Fam.: Dipterocarpaceae) which occur in Sarawak, East Malaysia [1].

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These are large forest trees which, in addition to bearing illipe nuts, yield common utility timbers belonging to the red meranti, dark red meranti and selangan batu groups.

In Sarawak, the fruits from *Shorea spp.* are known as engkabang. Nearly 200 species of *Shorea* occur in the Borneo territories but only a few of them bear fruits which are large enough or sufficiently abundant to be of commercial importance. The more important species are listed in Table I [2].

TABLE I. SHOREA SPECIES WHICH ARE COMMERCIALLY IMPORTANT AS ILLIPE NUT SOURCES

Botanical Name	Vernacular Name in Sarawak
Shorea havilandii Brandis	Engkabang pinang
Shorea hemsleyana (Mig.) King	Engkabang gading
Shorea fallax Meijer	Engkabang layar
Shorea macrantha Brandis	Engkabang bungkus
Shorea macrophylla (de Vr.) Ashton	Engkabang jantong
Shorea palembanica Miq.	Engkabang asu
Shorea seminis (de Vr.) V.Sl.	Engkabang terendak or Tegelam
Shorea Smithiana Sym.	Engkabang rambai
Shorea splendida (de Vr.) Ashton	Engkabang bintang
Shorea stenoptera Burck	Engkabang rusa or Engkabang kerangas

Vernacular names cannot be relied on to any substantial extent. For example, the name 'engkabang pinang' is applied to all species in the selangan batu group, the majority of which bear small seeds of no commercial value.

The value of individual species must be considered from two aspects, that is, through the eyes of the collector and from the view point of the fat extractor and refiner. The collector places a high value of the ease of collection of the fruits and on their size: thus *Shorea macrophylla* is highly valued because it grows in comparative abundance along the banks of rivers where collection is easy, also its fruits are of a large size; indeed this species provides approximately 85% of all illipe kernels exported from Sarawak. On the other hand, *Shorea hemsleyana*, although bearing fruit of good size, normally grows on swampy land and seldom in aggregations; therefore, its fruits are difficult to collect and, in consequence, are of little interest to collectors.

Fruits from *Shorea* spp. vary considerably in appearance. All species possess the persistant five calyx, typical of the Dipterocarpaceae, surrounding a thin woody shell encasing the four segmented kernel. The fruits vary in size within individual species as well as inter-specifically. For example, the largest specimen measured during this study was a fruit from *Shorea macrophylla* which was 7cm long on the major axis and 5cm on the minor axis; the average size of fruits from this species was 4.5cm x 3.0cm.

The smallest fruits measured were from *Shorea seminis* and *Shorea palembanica*, in each case 1.5cm x 1.0cm.

Fruiting of the *Shorea* species is irregular and good crops are fairly infrequent; this is attributable to the following influencing factors [2 & 3]:-

1. Natural periodicity of individual trees with regard to flowering.
2. Weather conditions prior to the onset of flowering seem to influence its intensity. If a tree is approaching a flowering period, dry weather in July and August appears to induce flowering.
3. The Landas (North-East Monsoon) normally sets in about the middle of October in Sarawak and if, as often happens, the break of the monsoon occurs early and with very heavy storms of wind and rain the blossom and immature seeds are stripped from the trees.

Although flowering and fruits setting normally occurs during the period immediately preceding the wet season and mature fruits normally fall from the trees during the period February to May of the following year, flowering occasionally occurs after the wet season and small quantities of fruit fall towards the end of the same year. According to available records, good 'spring' crops are quite often followed by small 'autumn' crops.

The fat extracted from the kernels of *Shorea* fruits is known as Illipe Butter or Borneo Tallow; it has been referred to commercially as Green Butter, a term often applied to a small group of solid fats which bear a physical resemblance to Cocoa Butter. Unlike Cocoa Butter, Illipe Butter cannot be used in the crude state but must be refined; the refined butter varies in colour from cream to pale green, has a complete melting point of approximately 37°C and possesses good stability.

Illipe Butter closely resembles Cocoa Butter both chemically and physically, but differs from the well known solid fats of the lauric acid group in that it is harder and more brittle but at the same time melts over a narrower temperature range; it does not contain glycerides with fatty acids of low molecular weight. Like Cocoa Butter it has a fairly simple fatty acid and glyceride configuration. The average fatty acid composition of Illipe Butter has been reported as follows [4]:-

Palmitic acid	-	21%
Stearic acid	-	41%
Oleic acid	-	38%

After fat extraction, the residual cake from kernels of *Shorea* fruits is used as an ingredient in the manufacture of compound animal foods. It has a low protein content.

TRADE IN ILLIPE NUTS - ITS IMPORTANCE TO THE PEOPLES OF SARAWAK:

Illipe nuts are collected mainly by the indigenous peoples of Sarawak. Collecting areas are defined by local custom and the operation is regulated by Forest Rules established by the Forest

Department. The most active collectors are Sea Dayaks, Land Dayaks and Kayan. The sale of marketable quantities of this oilseed is of considerable socio-economic importance to these people. Illipe nuts, being an uncultivated forest product, have no production cost and very little investment of funds is required for their primary preparation and handling. Net return to the collector is usually good in relation to the export value of the commodity and much better than that obtainable from agricultural products.

Collectors are predominantly subsistence farmers who traditionally practise shifting cultivation. They invest a considerable amount of labour in gathering, transporting, shelling and drying *Shorea* fruits at a period of the year when the annual rice harvest requires substantial attention. In return they generally obtain an extremely useful inflow of hard cash - trade is stimulated throughout the country and outstanding debts can be cleared so that commercial and rural activities are invigorated. This economic windfall is important, in good illipe nut years the commodity features high on the list of exports as an earner for the country and a large portion of this money does reach the rural community. Table II [5] gives some indication of the status of the commodity as an export item and Table III [6] lists the quantity and value of illipe nuts exported from Sarawak during the period 1948 to 1968 (inclusive).

TABLE II. Value of Principal Exports From Sarawak in 1954, 1958, 1959 and 1962.

Commodity	Value in Malaysian Dollars			
	1954	1958	1959	1962
Illipe nuts	12,631,295	7,119,738	19,967,395	16,011,630
Rubber	31,087,822	60,430,509	94,898,236	72,597,147
White pepper	9,529,122	9,986,059	15,616,475	16,100,259
Black pepper	34,177,391	5,157,561	2,481,345	7,786,593
Sago flour	2,828,635	2,345,107	2,399,769	4,169,921
Jelutong	3,130,801	1,633,611	1,557,072	1,761,978
Round timber	3,800,555	3,834,364	11,794,528	23,777,280
Sawn timber	10,079,397	15,734,178	19,245,943	17,058,084

Prices offered for illipe nuts must be related to the anticipated fat yield and also to the cost of the extraction and refining operation. Historical performance in regard to the yield factor must be of key importance in making an empiric valuation. The lack of continuity and regularity in the trade will detract from the accuracy of estimates in this regard.

It has been stated in the trade and elsewhere on a number of occasions that the operation of collecting, drying, buying and shipping illipe nuts is such a 'hit and miss' affair that it is surprising that overseas buyers interest themselves in the business at all. Presumably the export purchase prices paid are tailored to accommodate the inconvenience associated with the operation

as well as the inherent condition of the commodity which the refiners expect to receive. It is indeed encouraging that there is, in spite of the difficulties and deficiencies, a strong interest in illipe nut availability: if the commodity could be more thoroughly controlled and upgraded from the point of view of condition and quality at the time of export shipment it would be reasonable to expect that it could command a better price and that it would be a more attractive shipping proposition.

TABLE III. Exportation of Illipe Nuts From Sarawak - 1948 to 1968 (Inclusive).

Year	Tons Exported	Value (Malaysian Dollars)
1948	22	5,061
1949	752	444,970
1951	22	9.272
1952	30	15,465
1953	2,807	2,141,873
1954	16,047	12,631,295
1955	1,452	873,213
1956	158	92,198
1958	6,205	7,119,738
1959	22,006	19,967,395
1961	15	14,101
1962	19,883	16,011,630
1965	502	371,797
1966	6,761	4,605,240
1968 Estimated	15,000	12,600,000

COLLECTING, HANDLING AND PROCESSING OF ILLIPE NUTS AT THE COLLECTOR LEVEL: Once the fruits are ripe, collecting depends on the blowing of the wind - the stronger the wind blows the greater is the quantity of ripe fruits which drop. Collection of fruits by lopping off branches or by inducing fall by lighting fires under the trees is prohibited by Forest Rule. A variety of preparations are allowed in order to facilitate collection from both land and water; for example, undergrowth is slashed and booms are set up across streams and rivers so that they will catch floating fruits without inhibiting the passage of longboats.

Shorea fruits are incapable of resting; they germinate almost at once after falling from the parent tree. Growth of the embryo appears to be accelerated when the fruits are piled up for temporary storage prior to decortication. Rapid collection and early, adequate drying are essential if qualitative deterioration is to be minimised - germination seriously reduces fat content and increases free fatty acid content of illipe nuts. Cotyledons picked from seedlings had a fat content of only 8.7% (moisture free basis) and a free fatty acid content of 87.9% (measured as oleic acid): spent cotyledons, which had been shed from slightly more mature seedlings, had a fat content of 4.1% (moisture free

basis) and a free fatty acid content of 63.8% (measured as oleic acid). In comparison, sound average quality illipe nuts from *Shorea macrophylla* have the potential to yield approximately 50% fat (on a moisture free basis) and have a free fatty acid content of less than 3%. Unfortunately, spent cotyledons are sometimes collected and mixed with sound illipe nuts, to the overall detriment of the quality of parcels concerned.

Freshly fallen fruits have a moisture content in the range 43 to 47% (wet basis). The equilibrium moisture content in *Shorea macrophylla* kernels at 70% R.H. and 27°C is 6.9% (wet basis) [7]. Obviously, extensive and thorough drying is essential if deterioration resulting from infection by microorganisms, particularly microfungi, is to be minimised.

Insects exist which breed in and feed on seeds of the Dipterocarpaceae; in some seasons hardly any seeds are spared by these pests. Some insect damage is incurred by fruits on the tree; for example, one collection of *Shorea macrophylla* fruits still attached to the parent trees revealed that 18.6% of the kernels were bored and another collection of the same species from a different forest area was damaged to the extent of 5%. However, by far the greatest amount of damage is caused by insects which attack the fruits after they fall from the tree and before they are shelled and/or dried. Insect species recorded during a study of *Shorea macrophylla* fruits temporarily stored in heaps prior to shelling and/or drying are listed in Table IV.

TABLE IV. Insect Species Recorded in Undried Fruits of *Shorea macrophylla*.

Lepidoptera	
Galleriinae sp.	(Fam: Galleriidae)
Tirathaba sp.	(Fam: Pyralidae)
Aegeria nautica	(Fam: Aegeriidae)
Laspeyresia sp.	(Fam: Eucosmidae)
Coleoptera	
Nanophyes sp.	(Fam: Curculionidae)
curculionid sp.	(Fam: Curculionidae)
Poecilips gedeanus	(Fam: Scolytinae)
Poecilips nephelii	(Fam: Scolytinae)
Dryocoetes taprobanus	(Fam: Scolytinae)

The occurrence of *Aegeria nautica* was most interesting as the species is fairly rare and it had already been recored in association with *Shorea* fruits in Kalimantan [8]. Aegeriidae larvae are best known as tunnellers in branches and tree trunks.

The species of *Laspeyresia* and *Tirathaba* encountered were attacking fully ripe fruits and causing quite extensive damage.

Poecilips gedeanus is a noted pest of Dipterocarpaceae seeds [9]; a number of workers have recorded that it is extremely injurious to *Shorea* fruits which are not collected immediately after falling from the parent tree and either thoroughly dried without delay or temporarily stored under water. This species appears to only attack fruits after they have fallen from the tree, extensive tunnels are formed in the kernels.

Poecilips nephelii and *Dryocoetes taprobanus* were recorded as frequently as *P. gedeanus* in *Shorea* fruits in temporary storage heaps and on the floor of the jungle.

Nanophyes species lay their eggs on or in the fruits while they are still attached to the parent tree and apparently safe from attack by *P. gedeanus*, *P. nephelii* and *D. taprobanus*. Fruits successfully infested by both *Nanophyes sp.* and *P. gedeanus* were not recorded.

The insects which attack *Shorea* fruits on the parent tree, on the ground after they have fallen, and prior to drying by the collectors cause much more direct damage to the kernels (illipe nuts) than the species which succeed them during storage and handling operations after drying. These forest insects also expose the kernels to early and extensive infection by microorganisms.

Illipe nuts are almost invariably heavily infected with microflora at an early stage following collection and this state persists. It is these fungi which, together with insect activity, extensively infiltrate and damage the structure of the commodity promoting chemical degradation of the fat content into free fatty acids and other waste substances.

Fungal infections supported on insufficiently dried illipe nuts encourage infestation by mycetophagous insect species and species which can feed on the damaged commodity.

Traditional methods of temporarily storing freshly collected fruits, shelling, and drying are available which could be modified without radical change to enhance their efficiency and, thereby, considerably reduce biological damage to the kernels.

INFESTATION OF ILLIPE NUTS BY STORED-PRODUCT INSECTS: Illipe nuts, because of the condition in which they are normally stored, attract a rich insect fauna. However, it would be incorrect to consider all of the species which have been recorded on this commodity to be stored-product insect pests.

Comparatively little direct physical damage is caused by insects to illipe nuts during the period between primary drying and exportation. However, the presence of insects in the abundance normally encountered on this commodity is important, irrespective of the potential of the species concerned to cause direct damage to it, for the following reasons:-

(a) Insect activity contributes to the spread of fungal infection.
(b) International transfer of some of the species recorded is undesirable.
(c) Carrying vessels are cross-infested from the commodity.

(d) Other commodities temporarily stored or transported in close proximity to infested illipe nut parcels acquire cross-infestation. The significance of insect infestation on some commodities may be far more serious than would be the presence of the same species on illipe nuts.

Ninety-five species belonging to sixty-nine genera have been recorded on illipe nuts either in Sarawak or on discharge of cargoes at British ports [10]. Twenty species belonging to twenty genera were recorded in Sarawak but never in Britain whereas twenty species belonging to eighteen genera were recorded in Britain but not in Sarawak; the latter group is particularly important because it includes *Trogoderma granarium* and *Trogoderma inclusum*, species which must have been acquired in transit between Sarawak and Britain.

The most important species, as indicated by records compiled by the Ministry of Agriculture, Fisheries & Food, Britain, are listed in Table V [11].

Whereas substantial physical damage is not caused by insects prior to exportation of the commodity, some parcels are quite seriously attacked by *Araecarus fasciculatus* during the period of shipping to overseas destinations. This species only occurred in small numbers in association with illipe nuts in Sarawak but populations in some parcels examined on discharge at a British port were very substantial.

Deterioration of the fat content of the commodity continues during the period of export shipment. This degradation is assisted by biological heating within cargoes during shipment from Sarawak to Singapore and also during onward transportation from Singapore. Cargo temperatures in excess of 60°C have been reported to occur in parcels of illipe nuts prior to discharge at Singapore. A detailed study of the physical behaviour of a number of parcels of illipe nuts transhipped from that port to Britain revealed that temperatures rose to 45°C in parts of the stowage.

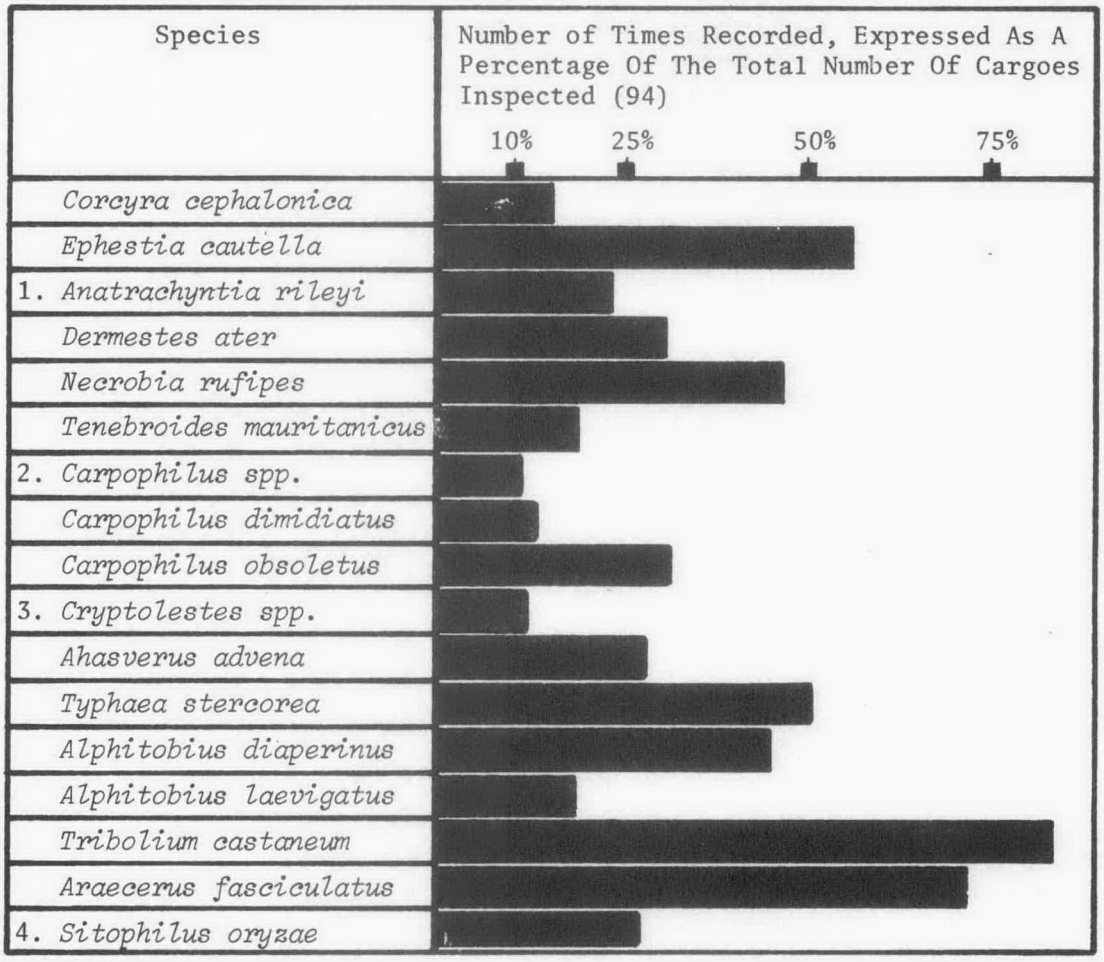
An indication of the extent of degradation during the period between the time of fruit fall from the parent tree and delivery to an overseas extraction plant is provided in Table VI. Quite apart from the reduction in fat yield and increase in free fatty acid content, refining of Illipe Butter to remove decomposition products is extremely wasteful.

CONCLUDING COMMENTS: Improvement in the quality and condition of illipe nut parcels at the time of exportation from Sarawak could be achieved by:-

(a) selective collection and careful storage prior to drying;
(b) thorough drying to an adequately low moisture content; and
(c) fumigation prior to export shipment.

If these procedures were carried out efficiently, a considerable improvement could be expected in the actual value of the commodity

TABLE V. Insect Species Recorded By The Ministry of Agriculture, Fisheries And Food, Britain, In More Than 10% Of All Cargoes Of Illipe Nuts Inspected During The Period 1953 to 1963.



1. It is interesting to note that no specimen of *A. rileyi* (syn. *Pyroderces rileyi*) was collected during field studies in Sarawak although many infestations of a *Pyroderces sp.* (nr. *falcatella*) were recorded.
2. Eight *Carpophilus* species, *Urophorus humeralis*, *Trimenus adpressus* and *Haptoneus luteolus* have been recorded on illipe nuts.
3. Four *Cryptolestes* species have been recorded on illipe nuts.
4. This analysis for *Sitophilus oryzae* possibly includes *S. zeamais*. *S. zeamais* was frequently found on illipe nuts, maize and rice in Sarawak.

as delivered to the fat extractor. It would be reasonable to assume that this would reflect favourably on the return to everyone interested in the trade in Sarawak, so that there would be more than sufficient compensation for the extra effort and expense required to attain the improvement.

Unfortunately, although solution of the problem appears to be simple enough in terms of technology, it certainly would not

be so in practise. Poor communication between the end users and the collectors, perennial uncertainty of any crop availability, complex internal trading arrangements, and difficulty in reaching and advising the collectors are all factors which inhibit improvement in the hygiene and quality of illipe nuts at their point of entry into international trade. Solution of the problem is as dependant on industry administration and organisation as on either scientific understanding of its nature or availability of sophisticated technical knowledge relating to methods of achieving improvement. This fact pertains to storage problems in virtually all industries but it is especially relevant to commodities like illipe nuts, which are produced, stored and marketed in a fragmentary manner.

TABLE VI. Free Fatty Acid Content (As Oleic Acid) of Illipe Nuts At Various Stages of Handling.

	Control Samples Specially Collected And Dried in Sarawak	Samples Collected Prior To Shipment Of Parcels From Sarawak Ports	Samples Collected From Shipments Discharged At Hull, Britain
Number of Samples In Survey	7	11	46
Average Free Fatty Acid	0.64%	5.93%	12.7%
Range of Free Fatty Acid	0.20 to 1.7%	2.73 to 11.3%	8.2 to 17.6%

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