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An Interpretation of the Present Range of Distribution and Dispersal of *Ochrosia oppositifolia* (Lam.) K. Schum. (Apocynaceae) in the Philippine Beach Forest

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Abstract

The Philippine populations of *Ochrosia oppositifolia* (Lam.) K. Schum. (Apocynaceae) are restricted only to three localities in Western Philippines: Basilan Island, Zamboanga Peninsula and Lubang Island, Occidental Mindoro. Such range of distribution indicates that the Philippine populations may have originated from Western Malesia region where the plant is widely distributed. The fruit morphology of this plant suggests hydrochore dispersal with long dispersal ability. However, the limited range of distribution of *O. oppositifolia* in the Philippines implies that the species is possibly a late emigrant into the Philippine Islands with the other species from Western Malesia such as *Artocarpus superba* Beccari, *Mallotus miquelianus* (Scheff.) Boere., *Mezoneurum sumatranum* (Roxb.) W. & A. and others. The presence of the postulated Borneo-Palawan and Borneo-Sulu land bridges during the Pleistocene (1.6 million years B. P.) and the Recent (10 thousand years B. P.) may have greatly aided plant dispersal by serving as corridor and temporary habitat of plants during the course of migration to the Philippine Archipelago.

Introduction

Investigating the ecological aspect of a plant species, particularly distribution and dispersal yields many important information. Range and pattern of plant distribution could suggest possible origin of the plant, probable time and pathway of migration and the dispersal mechanisms involved. The result of such studies would be useful to a phytogeographer who needs information on the origin of a particular plant species. It would also be important for a taxonomist making descriptions in floristic studies. The morphologist who studies the form and structure of the adaptation of propagules for dispersal would also need the data. It is under this pretext that the present study on the distribution and dispersal of *Ochrosia oppositifolia* (Lam.) K. Schum. (Apocynaceae) [see Fig. 1 in 4] in the Philippine Islands is undertaken.

Ochrosia oppositifolia grows in forests along the seashores of tropical regions [2, 3, 13, 16, 18]. It has a wide distribution in the tropical and even subtropical islands [Fig. 1]. It is distributed in Admiralty Is. [16], Andaman Is. [3, 18], Ceylon [3, 13, 17], Fiji Is. [13], Guam and Madagascar [16], Java [13], Mariana Is. [3, 17], Ellice Is. [13], New Caledonia [13], Malaya [13, 16, 18] and Thailand [13]. It might be interesting to mention here the occurrence of a variety of *O. oppositifolia* on Okinawa Is., Japan [22, 26].

In the Philippines *O. oppositifolia* occurs only in very few places. Despite this, it is a prominent species in its habitat. It is abundant and has a strong resistance to long dry conditions. It dominates the beach forest [7, 9] and grows around agricultural fields, grasslands and human settlements near the forest. People take advantage of its shade and use the leaves as medicine for wounds [8, 9]. It can also grow in rocky places and disturbed environs. Despite its phytogeographically noticeable occurrence in the

Philippines, there are still insufficient investigations on the distribution of *O. oppositifolia* in the Philippines.

In this paper, the pattern and range of distribution and the dispersal of the Philippine populations of *O. oppositifolia* are investigated based on the field observations by the authors, herbarium studies and literature survey. Possible origin of the few Philippine populations is discussed.

Methods

To map the distribution of *O. oppositifolia*, visits to Philippine herbaria around the Greater Manila Area and Cebu Island were made. The Philippine National Herbarium (PNH) and the herbaria of the College of Forestry (LBC) and of the Institute of Biological Sciences (CAHP) of the University of the Philippines at Los Baños (UPLB) were visited by the senior author. Likewise, the herbaria of the Cebu State College of Science and Technology (CSCS) and the University of San Carlos (CEBU) in Cebu Island were also visited and checked. Available specimens were closely examined for correct identification and places of distribution were recorded. In addition, published accounts on the distribution of the species were also used to supplement the limited data gathered from the herbarium specimens. Furthermore, the field observations by the authors from Lubang Island were incorporated. Based on all these information, the probable origin of the Philippine populations of *O. oppositifolia* was deduced.

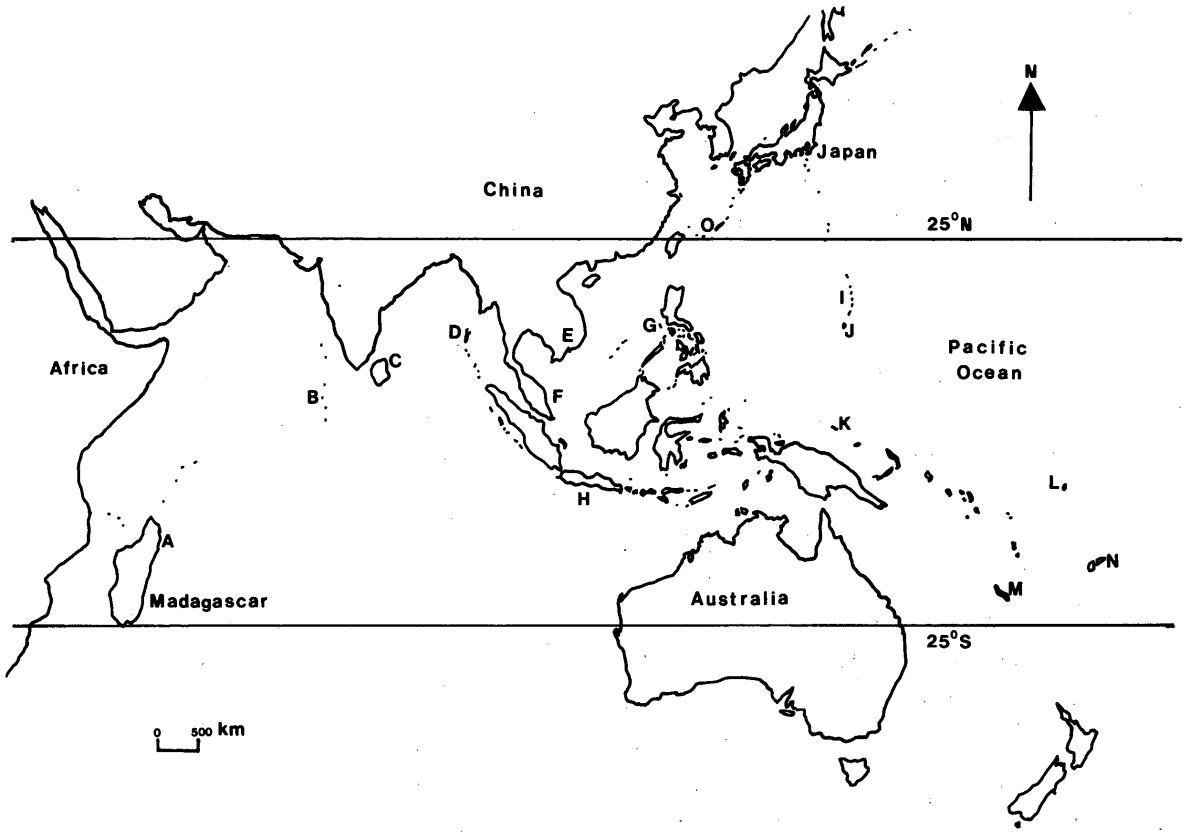

Fig. 1. A map showing the distribution of *Ochrosia oppositifolia* in the tropical and subtropical islands. A-Madagascar, B-Maldive Is., C-Ceylon, D-Andaman Is., E-Thailand, F-Malaya, G-Philippines, H-Java, I-Mariana Is., J-Guam, K-Admiralty Is., L-Ellice Is., M-New Caledonia, N-Fiji Is., O-Okinawa Is., Japan. The bold line represents the northern and southern limits of the tropical and sub-tropical regions. Note: Specific localities of distribution of *O. oppositifolia* cannot be indicated in detail on the map since the references (Floras) simply mentioned the name of the country or island.

Probable means of dispersal of the plant were also predicted on the bases of the present range of distribution and the fruit and seed morphology done in the laboratory. The dispersibility of the fruit of *O. oppositifolia* was then classified according to Carlquist's [10] scheme.

Results and Discussion

Distribution and possible origin

The herbarium studies and the review of past literatures showed that *O. oppositifolia* is found only in Western Philippines: Basilan Island (G), Zamboanga Peninsula (F) and Lubang Island, Occidental Mindoro (A) [Table 1 and Fig. 2]. Such range of distribution suggests that the Philippine population may have originated from the Western Malesia region where the plant is widely distributed [Fig. 1]. The Malesia phytogeographical region is actually composed of the Malay Peninsula, the islands of Java, Sumatra, Borneo, Celebes, New Guinea, Timor Islands and the Philippines [25]. The Western Malesia region specifically refers to the Malay Peninsula, Java, Sumatra and Borneo. The Philippine flora numbering about 14,490 species of plants composed of flowering plants (8000), ferns and fern allies (930), mosses (625), lichens (790), fungi (3000) and algae (1145) [1, 14, 15] is in general, essentially Malaysian, its chief alliances being with that of the Malay Archipelago [11].

Although *O. oppositifolia* is also found in the Pacific Islands, such as the Mariana Is. , Guam and the Admiralty Is. [Fig. 1], it could not be possible that the Philippine populations come from these islands situated east of the Philippines considering the present findings on the distribution pattern of the species in the Philippines, otherwise there would have been *O. oppositifolia* populations on the eastern part of the Philippine Archipelago. Therefore the only possible origin of the Philippine populations is the Western Malesia region particularly the Malay Peninsula and the Eastern, Western and Central Java regions.

Further examination of Fig. 2, reveals the restricted range of distribution of *O. oppositifolia* in the Philippines. This range is a characteristic feature of plants such as *Artocarpus superba* Beccari, *Mallotus miquelianus* (Scheff.) Boere., *Mezoneurum sumatranum* (Roxb.) W. & A. and others [Table 2] known as late emigrants from the Western Malesia region [11, 12, 21] during the Pleistocene (1.6 million years B. P.) and the Recent Period (10 thousand years B. P.) of the Cenozoic Era. Late emigrants refer to plant species originating from the Western Malesia region that do not extend their distribution to the other parts of the Philippine proper [21] but restricted to the Sulu Archipelago, Zamboanga Peninsula, Basilan Island, Balabac Island, Palawan and as far as Calamian Islands in the north [Fig. 2]. There are however few of the late emigrants reaching the West Mindoro (Occidental Mindoro) and Western Panay regions.

There have been some undocumented reports that *O. oppositifolia* is also growing in Palawan and Panay Island of Western Philippines. However such areas are excluded in the present range study due to the absence of voucher specimens deposited in herbaria and the lack of published accounts in the literatures. There is no report, either written or oral on the occurrence of *O. oppositifolia* in the intervening areas such as Balabac and Sulu where it can be expected to be growing. Nevertheless, it is safe to predict its presence in the Sulu Island group as evidenced by the existence of the local Sulu dialect, "ginlin" [18], referring to *O. oppositifolia*. The absence of distribution reports of *O. oppositifolia* in the aforementioned areas may be due to the need for more botanical exploration.

Table 2 is a sample list of some flowering plants distributed only in Palawan, Basilan Is., Zamboanga Peninsula, Mindoro and Sulu Archipelago. These species, like *O. oppositifolia* have limited range of distribution and are possibly late emigrants. They have important ecological roles in these areas just like *O. oppositifolia* on Lubang Island. Some take important role in developmental ecological processes like the *Ficus spp*. and *Mallotus miquelianus*. *Ficus spp*. and some members of Euphorbiaceae adapt well to certain habitats and are frequent elements of pioneering vegetation and early colonizers in forest succession [23]. Others take the role of enriching the soil conditions like *Indigofera galegoides* DC. and *Mezoneurum sumatranum*. These legumes have root

nodules that harbor nitrogen-fixing bacteria [24]. Others are promising ornamentals like the Arecaceae and the Orchidaceae.

Dispersal

Evidences from the pattern of distribution and fruit morphology [6] of *O. oppositifolia* point out that this plant is dispersed mainly by sea water in nearby

Table 1　Distribution of *Ochrosia oppositifolia* in the Philippines.

Locality	Reference
Basilan Island	[3, 18]
Zamboanga Peninsula	[18]
Lubang Island, Occidental Mindoro	[4, 5, 6, 7, 8, 9]
	Exsicc.-*Buot 41425, 41426; Hernaez 29377, 29378, 29379, 58835, 58836; Regalado 29258* (CAHP); *Buot and Aguilar 190, 191, 192, 193, 194, 195, 196* (CSCS)

* No specimen of *O. oppositifolia* collected from the Philippines exists in PNH, LBC and CEBU.

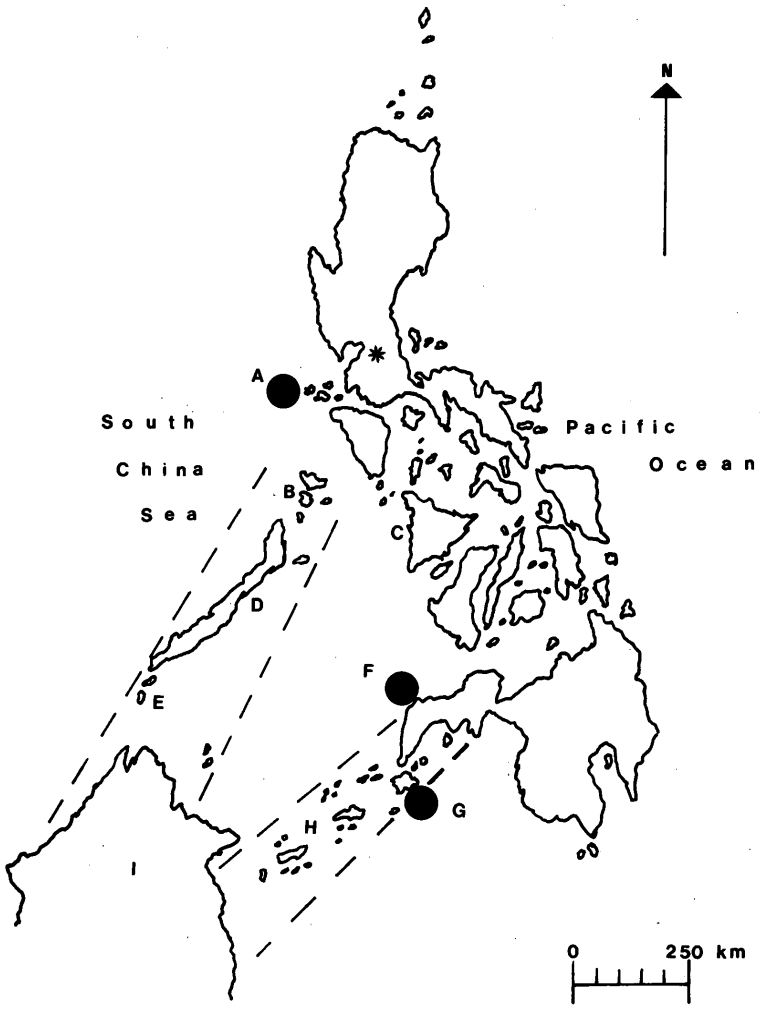

Fig. 2. Distribution of *Ochrosia oppositifolia* in the Philippines (as indicated in bold dots) and the postulated Borneo-Palawan and Borneo- Sulu land bridges (broken lines) during the Pleistocene. A-Lubang Is., Occidental Mindoro, B-Calamian Is., C-Panay, D-Palawan, E-Balabac Is., F-Zamboanga Peninsula, G-Basilan Is., H-Sulu Archipelago, I-Borneo. The asterisk (*) is the location of Manila. Original base map is modified from Dickerson [10].

islands. The fruit is a drupe [see Fig. 1b in 9] and the seed is well-protected by a thick and fibrous endocarp [see Fig. 13 in 9]. Bouyancy test in this study using saline solution to simulate ocean water conditions showed that the endocarp indeed exhibits bouyancy which could enable the diaspores to be transported through water medium. Merrill [20] remarked that species growing on or near the immediate vicinity of the strand like *O. oppositifolia* have definite adaptation for dissemination of fruits or seeds through the medium of ocean currents.

The attractive color of the fruit (deep red to violet when ripe) may lead a worker to think that this species could be dispersed by birds also. However the obvious presence of latex could deter birds from feeding on the fruit. Hence, hydrochore dispersal is considered here.

The sea water current in the Philippines has been described to be favorable for plant propagule dispersal [11]. It was noted that the ocean currents in the equatorial regions [including the Philippines] are deflected in a northerly direction by Java, Sumatra and the Malay Peninsula into the South China Sea. Likewise the equatorial temperatures are shifted northward to a certain extent in the waters west of the Philippines. Such prevailing ocean currents in the Philippine waters have a great equalizing influence. And since this current has probably been constant during the Pleistocene and the Recent, sufficient time has been provided for the migration and dispersal of plants [and even animals for that matter] without necessarily disrupting the physiology of the diaspore even if it travels over a long distance.

Carlquist [10] classified the dispersibility of island plants as (1) poor if seeds and fruits are large and heavy but not fleshy, (2) fair if seeds and fruits are not floating but fleshy and large seeds, (3) good if the fruits are fleshy and small, (4) very good if the diaspores have adhesive barbed structure adapted for transport by birds, and (5) excellent if seeds are primarily dispersed by wind and water. As per Carlquist's classification then, the dispersibility of *O. oppositifolia* is categorized as excellent.

Hence it is not a surprise that *O. oppositifolia* is a dominant component in the Lubang Island beach forest as had been reported in many studies [4, 6, 7, 8, 9] and that it is widely distributed in the tropics [2, 3, 13, 16, 18].

Possible role of land bridges

Early geologists [11, 12] working on the Tertiary and Quaternary palaeography of the Philippines suggest the presence of land bridges [Fig. 2] connecting Palawan and Borneo and Sulu and Borneo during

Table 2 List of some possible late emigrants together with *Ochrosia oppositifolia* into the Philippine Islands.

Family	Species	Range of distribution	Reference
Annonaceae	*Desmus cochinchinensis Lour.*	Palawan, Basilan, Zamboanga	[17]
	Mitrephora williamsii C. B. Rob.	Zamboanga	[17]
Arecaceae	*Oncosperma tigillaria* (Jack) Ridl.	Palawan	[19]
	Oraria paraguanensis Becc.	Palawan	[19]
Euphorbiaceae	*Mallotus miquelianus* (Scheff.) Boere.	Mindoro, Palawan	[17]
	Sumbaviopsis albicans (Blume) J. J. Sm.	Palawan	[17]
Leguminosae	*Indigofera galegoides* DC.	Palawan	[17]
	Mezoneurum sumatranum (Roxb.) W. & A.	Palawan	[17]
Moraceae	*Artocarpus superba* Beccari	Palawan	[11]
	Ficus glareosa Elm.	Palawan	[17]
	F. grandidens Merr.	Zamboanga	[17]
	F. pedunculosa Miq.	Palawan, Sulu	[17]
Piperaceae	*Piper subprostratum* C. DC.	Mindoro	[17]
Orchidaceae	*Cordula barbata* (Lindl.) Rolfe	Palawan	[19]
	Nervilia crispata (Blume) Schlter.	Palawan	[19]
Rutaceae	*Clausena excavata* Burm. f.	Mindoro, Palawan, Sulu	[17]

the Pleistocene and the Recent. They contend that the land bridges facilitated plant dispersal by serving as corridor providing an unimpeded route of plant migration. This implies that during the course of long distance migration, plants must have established temporarily on the land bridge before finally reaching the Philippine Islands.

Dickerson [11] emphasized the need to consider the theory on the existence of the land bridge to account for and satisfactorily explain the high number of Western Malesian flora in the Philippines. This is especially true for plants with poor dispersal mechanism and capability though Dickerson [12] asserts that even plants with excellent dispersal means must have made use of the land bridge which provided an unobstructed pathway of migration.

It is therefore possible that *O. oppositifolia* must have passed through this Borneo-Sulu and Borneo-Palawan land bridges which served as corridor together with the other late emigrants [Table 2] during plant migration in the past.

Summary and Conclusion

An interpretation of the present range of distribution and dispersal of *Ochrosia oppositifolia* (Lam.) K. Schum. (Apocynaceae) in the Philippine beach forest was done. Field visits, laboratory and herbarium studies were made to determine the range of distribution and dispersibility of the species. Data show that *O. oppositifolia* is distributed only in Basilan Island, Zamboanga Peninsula and Lubang Island, Occidental Mindoro. Its diaspores are fit to cover long distances measurable in kilometers via water current and therefore its dispersal capability is interpreted as excellent, hence its dominance on the Lubang Island and its wide distribution in the tropics and subtropics. Philippine populations are predicted to be late emigrants originating from the Western Malesia region during the Pleistocene (1.6 million years B. P.) and the Recent Period (10 thousand years B. P.) of the Cenozoic Era.

Early geologists assert that the postulated Borneo-Palawan and Borneo-Sulu land bridges played an important role in plant dispersal. They may be right as the land bridges could have served as corridor and temporary habitat during the long course of plant migration into the Philippine Islands.

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フィリピンの海岸林に生育する*Ochrosia oppositifolia* (Lam.) K. Schum.（キョウチクトウ科）の現在の分布範囲と散布様式についての考察

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摘　要

フィリピンの海岸林に生育する*Ochrosia oppositifolia* (Lam.) K. Schum.（キョウチクトウ科）の現在の分布範囲を明らかにし，散布様式を検討することで分布の成立過程を議論した．シマソケイ；*O. oppositifolia*はマレーシアから太平洋諸島を中心に広く分布するが，フィリピンでは西部のバシラン島とミンダナオ島西部のザンボアンガ半島およびルバング島の3カ所に限って分布する．このような分布様式から，植物はフィリピンには西マレーシアから渡ってきたものと考えられる．果実の形態などから，この植物は海流による散布で長い距離を移動可能といえる．それにも関わらずフィリピンでの分布域が限定されていることから，西マレーシアから比較的最近渡ってきたものと考えられる．そのような植物には他に*Artocarpus superba* Beccari, *Mallotus miquelianus* (Scheff.) Boere., *Mezoneurum sumatranum* (Roxb.) W. et A.などがある．更新世から完新世にかけて存在したと推定されているボルネオーパラワン陸橋とボルネオースル陸橋が海岸伝いの回廊の役割を果たし，そこを通ることによって，フィリピンへの移動がかなり容易になったものと推定される．