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A survey on agarwood in Vietnam

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Abstract

Agarwood is a one of the most valuable minor forest products of the Southeast Asian tropical forests. In Vietnam agarwood is produced from the heartwood of rarely available natural *Aquilaria crassna* trees (Thymelaeaceae). In our field work in Vietnam, a natural *A. crassna* was found in Khanh Hoa Province. Information on agarwood exploitation and production were also gathered by interviewing the local people. The result showed that part of the local people earn their living by dealing with agarwood, but due to over exploitation the natural resource for this valuable plant has declined dramatically in the past decades, while the demand for the resource remains constant or even increases. The cultivation of *A. crassna* has been started in several places in the country as an initiative for conserving this endangered but economically important plant species.

Key words agarwood, jinko, *Aquilaria crassna*, Vietnam.

Introduction

Agarwood (also known as aloeswood, eaglewood), jinko (沈香) in Japanese or tram huong in Vietnamese, literally means "incense from the wood that sinks", is a highly valuable resinous fragrant heartwood produced principally from tropical trees in the genus *Aquilaria* (Thymelaeaceae). Agarwood incense has been used for their fragrant properties for thousand years, mainly in Asia, in religious ceremonies by Buddhists.

Tropical Southeast Asian countries such as Cambodia, Indonesia, Malaysia and Vietnam are major countries of origin for agarwood, in which, the Vietnamese tropical forest is considered to be a rich source of high quality agarwood.[1] However, little is known about Vietnamese agarwood exploitation and production so far.

Agarwood is a famous and valuable product in Vietnam. The production is restricted to the rare natural *Aquilaria crassna* trees, which is indigenous to the country. It is now cultivated most in Phu Quoc Island and Khanh Hoa Province. In our two-year project on Vietnamese traditional medicine plants, we did not visit the cultivation sites, but we have conducted research and survey on agarwood production in Vietnam by interviewing local villagers and people dealing with agarwood mostly in Khanh Hoa Province. Interestingly, we have found a live natural *A. crassna* tree, which showed agarwood was producing. Here, we would like to report our observations together with the experience and knowledge of local people regarding agarwood production and exploitation in Vietnam together with its present status.

Results and Discussion

The Aquilaria tree and agarwood

Aquilaria genus comprises of 15 species, family Thymelaeaceae. Among them, *A. crassna* PIERRE ex LECOMTE, which habitats in Indochina's peninsula, is the major source plant for agarwood in Vietnam. This species is considered to be one of the *Aquilaria* species producing high quality agarwood.[2]

A. crassna is a large evergreen wood tree, growing over 15-30 m tall and 1.5-2.5 m in diameter. It has alter-

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nate laminated leaves of 6-11 cm long, white umbellate flowers. Except *A. crassna*, other species such as *A. agallocha*, *A. baillonii* and *A. banaensae* are also claimed to present in Vietnam.[1,3] But these claims are still in conflict. According to the agarwood collectors in Khanh Hoa province in Central Vietnam, they often encounter two kinds of *Aquilaria* trees in forest, one is *A. crassna* with round leaves, which they called "do bau" and the other with narrower leaves called "do me" (Fig. 1.A). The two *Aquilaria* species were told to produce agarwood equally, therefore, local people collect agarwood from them without discrimination. To the best of our knowledge, no scientific information is available on the later *Aquilaria* species with narrow leaves. Study is necessary to determine the scientific name of this *Aquilaria* species.

Hypotheses exist regarding agarwood formation. It is believed that agarwood is due to an immunological response of the host tree upon wound and/or infection. It may be the result of pathological, wounding/pathological and/or pathological processes.[2] However, studies have not provided conclusive evidence for any of these hypotheses.

According to the experience of local people, once the tree has been wounded, which may be caused by birds, insects such as ants, or when branches are broken by wind, the heartwood of the tree is exposed and subsequently infected by bacteria or fungi. Upon infection, discoloration occurs, i.e. the exposed wood part gradually turns dark, and gradually invades into the deep heartwood. As a result, part of the wood of the trunk turns dark or black, which is the source of the incense resin. The last invasion process is believed to be important for producing agarwood of high quality, i.e. the longer the process, the thicker the dark agarwood layer, the higher the quality, which requires from several years to decades. And agarwood is believed to be formed only in alive *Aquilaria* trees. Therefore, it is suggested that agarwood is a kind of secondary metabolism by a living tree, which cannot occur in dead trees. To help the tree in producing agarwood people also make wounds on the trunk by slicing off the bark to expose the heartwood.

Not all *Aquilaria* trees produce agarwood, according to agarwood collectors, approximately 20% of natural trees is estimated to produce the resin. Only mature trees above 20 cm diameter at breast height (dbh) produce agarwood, and infected trees produce resin from the age of 20 years onwards. Best yields are obtained from trees aged 50 years and over. However, some also believe that agarwood formation can occur in trees as young as three years of age.

Harvesting agarwood

On Sunday, November 24, 2002, with a guide of two local professional agarwood collectors, Mr. Ngo Huu Dang and Ngo Cung, an adult natural *Aquilaria* plant was found in Ba Muoi mountain, Ninh Tay village, Ninh Hoa district, Khanh Hoa province. The plant was about 10 years old, 20 cm dbh and 10 m height. It had been artificially wounded with a knife-cut at a position of 40 cm from the stump (Fig. 1.B). Discoloration occured in the wound and partially invaded into deep heartwood as evidenced by the appearance of dark wood when the outer sapwood was sliced off (Fig. 1.C). But the agarwood formed is still little for harvest and the collectors wanted to wait for a longer time for more agarwood production. When a small piece of wood, taken from the wound, was burned, the smoke had a low-quality-agarwood smell.

Near this *Aquilaria* tree, several *Aquilaria* saplings were found (Fig. 1.D). They were about three years of age, of 5 cm dbh, but knife cuts had already been made on their stems. Some of the wounds had turned dark but some were still fresh. Near those saplings, a trace of a big *Aquilaria* tree was found. It was a big hole, suggesting that the tree was more than 1 m dbh (Fig. 1.E). According to the collectors, the aerial stem and branches of the big tree was felled a long time ago for harvesting agarwood, and the stump was left gradually dead. But recently, agarwood was found in its dead roots. So people started to dig it up again for agarwood. What is left now is the big hole. Perhaps, those saplings we found were regenerated from the big one, which is now no longer present.

According to the collectors, agarwood is harvested by groups of 2 to 4 professional agarwood collectors. They carry with them food, knife, axe and necessary kitchenware. Their trip usually takes several weeks. The frequency of encountering an adult individual *Aquilaria* tree (above 20 cm dbh) is very low, i.e. less than 1 tree per day. The traditional approach to agarwood harvesting is to select carefully the target trees and only harvest from those individuals of *Aquilaria* that are believed to

Fig. 1 (**A**) The two different *Aquilaria* species found in the forest in Khanh Hoa province, "do me", the *Aquilaria* tree with narrow leaves (**a**) and "do bau"; *A. crassna* with round (egg-shape) leaves (**b**). (**B**) The wild *Aquilaria* tree found in Ba Muoi mountain. Discoloration occurred on the surface of the wound on the trunk. (**C**) The heartwood, exposed after the sapwood was sliced off, showed that the fibers had turned dark and discoloration was invading into the heartwood, suggesting that agarwood formation was in progress. (**D**) Several *Aquilaria* saplings were found around the site where the adult natural *Aquilaria* was found. Their trunks had already been wounded. (**E**) Trace of a huge *Aquilaria* tree was found. The man indicates that it was nearly 1 m dbh. (**F**) Cultivated *A. crassna* in Lam Ha District, Lam Dong province.

contain agarwood. As noted above, only a relatively small portion of *Aquilaria* trees likely to produce agarwood. Dying trees are thought especially to contain agarwood, indications that trees are dying including yellowish leaves, leafless branches with swollen spots along the branch and trunk and very dry bark. When an infected tree is identified, collectors simply fell it and slice off the bark and sapwood of the trunk or even the roots of the tree at the place which is suspected to contain agarwood. In case of a big tree, the trunk is cut into lengths of 50 cm and searched for darker portions of agarwood. After all the sapwood has been trimmed, the dark piece of wood which remains is raw agarwood, which is brought home.

Although infected trees apparently exhibit certain of the symptoms outlined above, it is not possible to identify agarwood-producing trees in a reliable manner by visual inspection. And because the number of *Aquilaria* trees become less in the forest and are rarely found, consequently, most of the collectors tend to fell most of the *Aquilaria* trees encountered in the search for those containing agarwood. That may be the reason that *Aquilaria crassna* is now listed as "critically endangered" in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Plants.[1)]

Processing and classification of agarwood

Raw agarwood brought home is not tradable. It must be processed to become commercial agarwood. Processing has two main purposes. One is to discard non-agarwood part, i.e. sapwood, to expose the dark color of agarwood. The second is to give it some kind of shape. In November 2001, we went to Xom Don village, Van Thang district, Khanh Hoa province. This village is also called agarwood village. People in the village earn their living by dealing with agarwood since ancient times, and they are famous not only in Khanh Hoa province but also in the country for doing so. They used to go to mountains for agarwood a long time ago, but recently, when its natural source declined, they stopped traveling but started buying raw agarwood from collectors and hiring workers to process it into a commercial product. Only few rich families in the village can do this. In the family of Mr. Hai Sung, there were 5-6 workers processing agarwood at the time we visited his family (Fig. 2.A). By using chisels (Fig. 2.A-C), they tried to discard the outer white wood part until the dark inner part of agarwood was completely exposed (Fig. 2B).

After being processed, agarwood is classified according to its quality. There are various grades for commercial agarwood. The special grade of agarwood, called "ky nam" in Vietnamese, is assigned to agarwood with highest quality. Lower quality is of normal agarwood. Within special or normal grade, it is further divided to first, second, third, ... grades (Fig. 2.E). Quality of agarwood is estimated by its appearance and smell. Special grade agarwood has a characteristic aroma, which can be smelled clearly without burning the wood chip. It is usually heavier than the one of normal grade. The formation of this special agarwood is believed to take nearly a hundred years, after such a long time, all the wood fibers have been "digested" into highest quality resin with most essential oil content. Therefore, all wood fibers of this highest agarwood should have a shining black to brown color. Its cost is most expensive, which may be more than 10,000 USD/kg. According to people dealing in the business, the high price of this grade of agarwood is not solely due to its high quality but due to its rareness. Indeed, while this grade of agarwood requires at least 50 years for its formation, exhaustive exploitation of *Aquilaria* trees in the past decades makes it almost impossible to find with any significant amount. What the agarwood collectors often bring back home is normal agarwood of lower quality. This grade is also divided further into first, second, ... sixth grade, depend on their color and aroma. In general, normal agarwood is lighter than the special one in weight. Its natural odor is also weaker, it is often necessary to burn the wood chip to evaluate the smell quality (Fig. 2.D). Its wood fibers are not transformed completely to agarwood, white wood fibers are still present alternating with the black part of agarwood. In general, the more the black part, or the less the white part, present, the higher grade the agarwood is. Depending on grade, normal agarwood may cost from 200 to 1,000 USD/kg. The shavings remained after agarwood processing, especially the wood layer just outside the dark part of agarwood, can be used to make powder for making incense sticks. It usually costs 10 USD/kg.

In addition, normal agarwood is also classified by its shape and appearance. "Tram bau", plate agarwood, is agarwood in the shape of a round plate (Fig. 3.A). It is

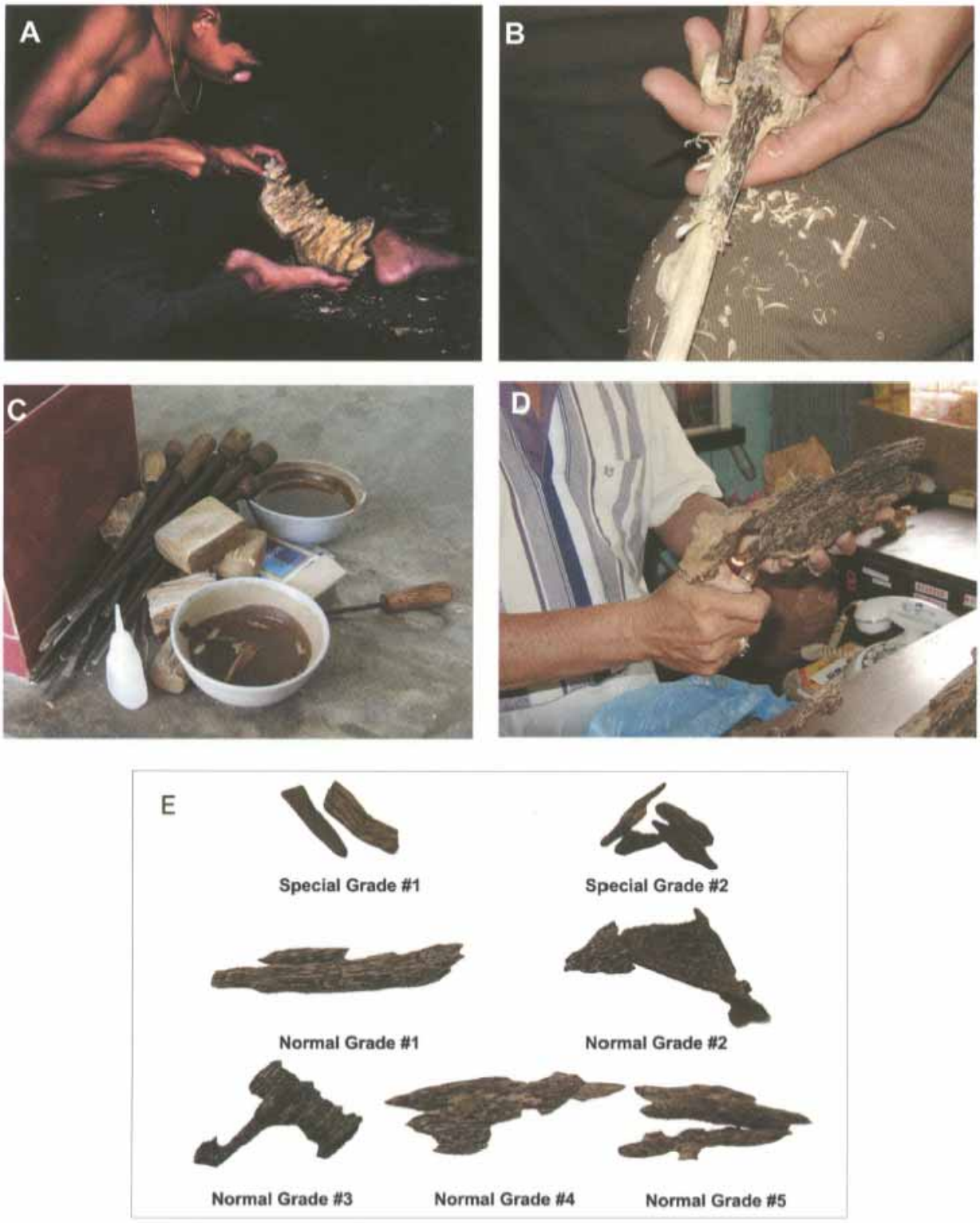

Fig. 2 (**A**) A villager is polishing the raw agarwood by using chisels in Xom Don Village, Van Thang district, Khanh Hoa province. (**B**) The dark color of agarwood appears after the sapwood was removed. The shavings coming from the nearest sapwood to the dark layer of agarwood, can be used for making incense sticks. (**C**) The chisels and tools used in polishing agarwood. (**D**) Burning agarwood chip to evaluate its aroma quality. (**E**) Commercial agarwood is graded into special and normal grades, which are classified further into first (#1) and second (#2), or until fifth (#5) subgrades. Special grade agarwoods have highest density and strongest aroma. Agarwoods of normal grade were lighter in weight, compared to the special one, and characterized by the presence of more white wood fibers. The more the white wood fibers present, the lower the quality.

Fig. 3 (**A**) Tram bau, agarwood with a plate-shape. (**B**) Tram kien, ant agarwood, formed from ants' nests. Many holes on a hollow piece of wood can be seen. (**C**) Tram toc, thread agarwood, possesses long black to brown wood fibers, alternating with white part. (**D**) An alcoholic tincture of special grade agarwood, which is common in families of Xom Don village.

taken from the top part of the trunk which remains after an *Aquilaria* tree has been felled. Quality of this kind of agarwood is judged by the thickness of the dark layer of agarwood. "Tram kien", ant agarwood, is believed to be formed when ants build their nest by making holes in the trunk or branch of *Aquilaria* trees (Fig. 3.B). Subsequently, the wood part around the ant's nest, i.e. the "wall" of the nest, transforms into agarwood. Therefore, "ant agarwood" has a shape of a long and hollow stem or branch. "Tram toc", thread agarwood, has random shapes but wood fibers, which are turned to agarwood with black color, can be seen like a long black thread on the background of white fibers (Fig 3.C).

Commercial agarwood is then brought to Hochiminh City for retail or for export. We visited some traditional medicine shops in district 5, Hochiminh city, where agarwood is traded. The products were varied, priced from US$ 10 to 500/kg. The cheapest one (US$ 10/kg) was said to be a powder of agarwood. It is to make incense sticks used in ceremonies in Buddhist temples. Others were agarwood of normal grade. But we could not exclude the possibility that some were fake products because of their strange smell and appearance. Some were likely pieces of wood impregnated with essential oil which does not have the characteristic aroma of agarwood.

Artificially cultivated Aquilaria

We visited Forest Seedlings Company, Ministry of Agriculture and Rural Development. According to Mr. Nguyen Thanh Phong, Deputy Director of the company, because of its economic importance, government plantations of *Aquilaria* trees, especially *A. crassna*, started from the 1980s in Phu Quoc Island, An Giang, Kien Giang and Khanh Hoa Provinces with seedlings provided by the company. The Flowering season of *A. crassna* is from May to September. However, the seeds are

produced most only once every four years, which allows the most successful harvest. Once collected, the seeds must be sown within 5 days, otherwise, germination possibility drops dramatically. Germinated seedlings can be readily grown in nursery conditions and then supplied for cultivation when they reach 5 cm height. Recently, the company developed a cloning method using callus culture to be independent from the seed collections. At the present time more than 300 adult *A. crassna* grow in a restricted location in Phu Quoc Island.

A landmark of *Aquilaria* tree cultivation is Khanh Hoa Province, which is considered to be a native land of agarwood. Many claim that the climatic and environmental conditions of Khanh Hoa Province is most favorable both for cultivation of the *Aquilaria* tree and for agarwood formation process. Indeed, the presence of natural *Aquilaria* trees in large number in the province was recorded in the late 19th and beginning of the 20th century by the French.[3] Artificial cultivation of this plant has been started since 1987 on Son Tap Mountain, Dai Lanh, Van Ninh, Khanh Hoa at an altitude of 550 m above sea level. According to Department of Science, Technology and Environment of Khanh Hoa Province, the area of *Aquilaria* plantation continues to increase year by year, which is totally more than 50 ha at the present time. Research was also conducted in the area on the possibility of artificial agarwood formation by inoculation of various fungi. Preliminary results were claimed to be promising but still far from expected. The study is in progress.

Aquilaria trees are also cultivated privately. Local people transplanted seedlings from nearby forest into their own gardens. Professionals also plant the *Aquilaria* in their farm with a more serious purpose, i.e. to produce agarwood, such as in Lam Dong Province (Fig. 1.F).

Uses of agarwood

Except its common use for incense, agarwood has been used for medicinal purposes for centuries in Vietnam and is included in Vietnamese pharmacoepia. It is best for nausea, abdominal pain, asthma.[3] Only agarwood of the special grade is considered to be medicinal grade. The high price of this agarwood may be the reason that most of traditional medicine practitioners we interviewed reported that they would use agarwood if it could be acquired at an acceptable price. However, local villagers in Xom Don village, especially agarwood collectors and dealers, always keep a small quantity of this grade of agarwood in their home for use in case of acute abdominal pain. In some families, a tincture of agarwood is made (Fig. 3.D). The tincture has a very hot taste and characteristic aroma of agarwood. Only a few drops can be used as a time. However, its use is prohibited for pregnant women.

Conclusion

As in other Asian countries,[4] agarwood is likely to have strong impact on Vietnamese culture and economy since ancient times. The benefit of agarwood to local people is significant, and it has become a major source of income for such communities, for example, in Xom Don Village, Van Thang, Khanh Hoa province. And thanks to their efforts, the high culture of incense in Asian countries has flourished. However, excessive of agarwood harvesting over thousands of years, together with high deforestation rates, has led to a dramatic decline in the natural *Aquilaria* species, while the demand for the resource remains constant or has even increased. A similar situation has been reported in other agarwood producing countries such as India and Indonesia.[5] Recently, artificial cultivation of *Aquilaria* trees in Vietnam has been recognized and launched as an initiative in conserving *Aquilaria* stocks. However, without an understanding of the mechanism of agarwood formation, all those efforts would not reduce the present high pressure on the natural resource. Further studies are needed to solve the puzzle of the mother nature.

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和文抄録

東南アジアにおいて医薬学的に価値のある希少な森林資源の一つである沈香は乱獲により減少している。我々は，ベトナムにおける沈香についての現状を調査する目的で，現地を訪問し，種々の情報を得た。今回，我々の調査において，Khanh Hoa 省でベトナムにおける沈香

の原木である数少ない自生の *Aquilaria crassna* を探し出すことが出来た。また，沈香の取引で生計を立てている現地人に聞き取り調査を行い，沈香の資源利用と加工工程についての情報を得た。さらに，植物種の資源保護のために *A. crassna* の栽培がベトナムの数カ所で始められていることを確認した。今後，栽培による資源の確保，沈香の生成メカニズムの解明が重要になると考えられる。

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