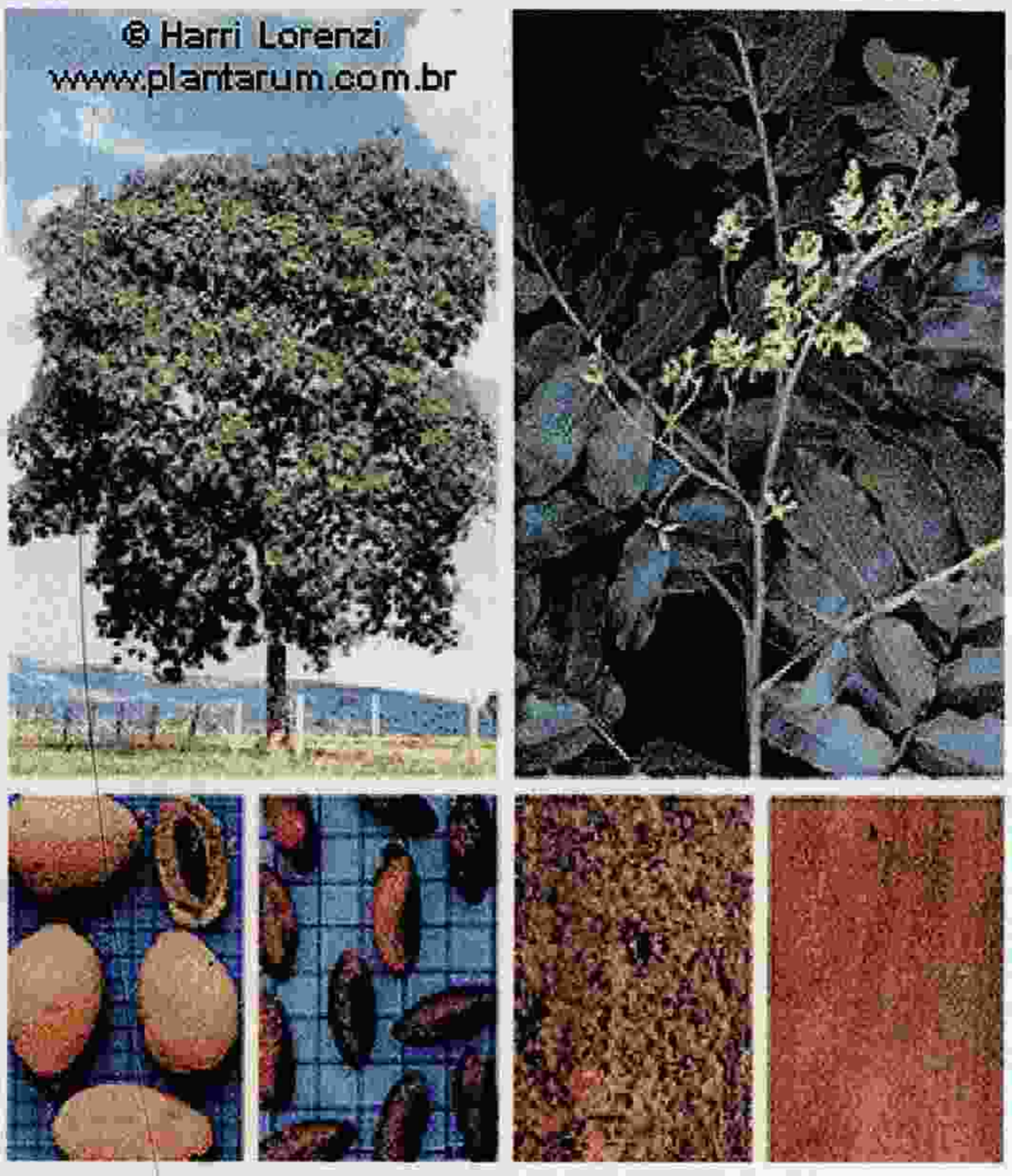
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Rebecca Latchford [07294]

Dissertation submitted in partial fulfilment of the requirements for MSc: - Forestry: Science, Policy and Management September 2002.

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Acknowledgements

Firstly I would like to sincerely thank Dr Stephen Harris, for his continued support and advice. I really appreciated his help throughout this dissertation, along with his permanent patience.

I would like also to thank the herbarium and library staff for their patient help throughout.

Also a special thank you to my friends from the MSc course for always being there to listen and help, especially Nick, Mary, Richard, Summer and Helen.

Abstract

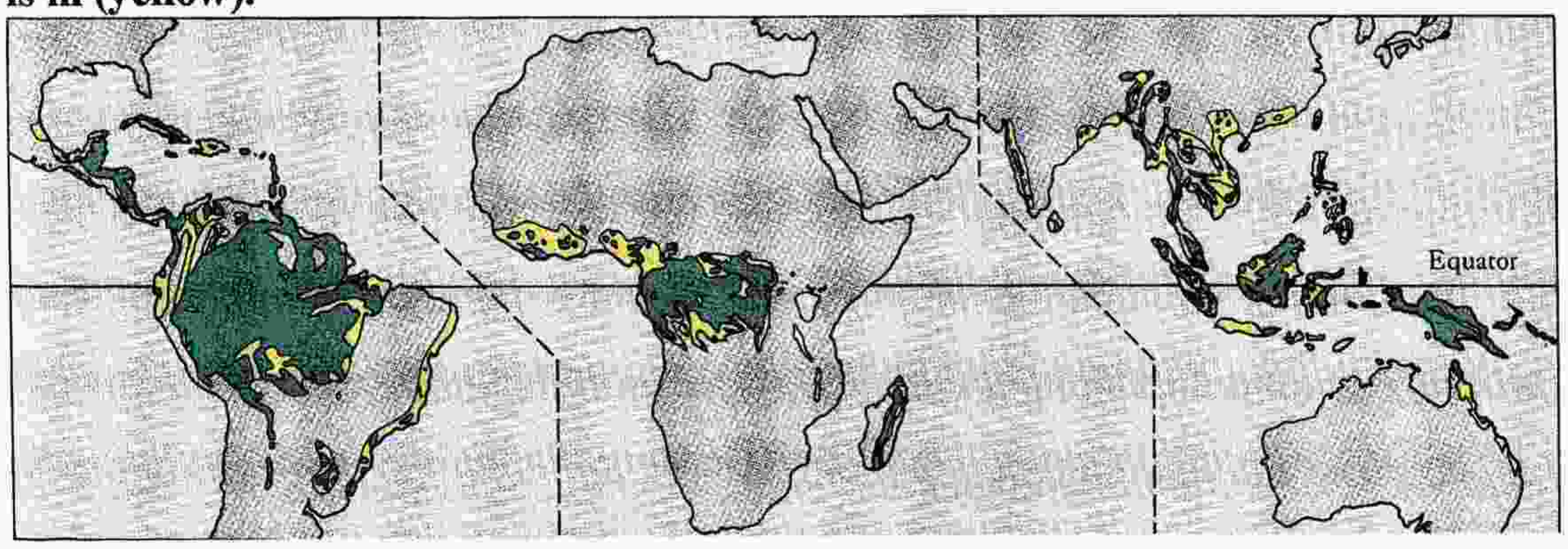
A monograph of the species *Dipteryx odorata* has been created for this dissertation. Different sources were consulted to determine the distribution natural, were it has a potential for a long history of use and were it is cultivated. The Description is given for the genus of *Dipteryx* and *D. odorata.* The species is mistaken for different species a list of this information was compiled. The relevant ecological data and uses of the timber and seeds of *D. odorata* was complied. Finally the wood characteristics were examined for the *D. odorata* and samples provided for other genera that were cited to have the same common or trade name as *D. odorata.*

Chapter 1 – Introduction

1.1. Tropical humid forest distribution

The neotropical humid forests have a vast distribution they are found mainly between 19^0 south and 10^0 north, with the largest continuous expanse of neotropical humid forest covering the Amazonian region (Terborgh 1992). In Uruguay, Paraguay and central Argentina there are patches of tropical humid forest, reaching its southern limit at approximately 36^0 south. The neotropical tropical humid forests are also found along the Atlantic coast of Central America through into southern Mexico, reaching their limit at approximate 22^0 north (Davis *et al.* 1997; Figure 1.1.1.).

Fig. 1.1.1. The current distribution of the humid tropical forests across the three continents (green), the largest expanse of humid tropical rainforest is found extending over the Amazonian basin, the former distribution of this forest type is in (yellow).



1.2. Forest species diversity

The humid forests of the neotropics are cited as the most species diverse terrestrial ecosystem that exists (Terborgh 1992, Davis *et al.* 1997, Wadsworth 1997). There are various estimations of the approximate number of tree species found per hectare. They can range from 100 to 300 tree species per hectare with a dbh >10cm (Terborgh 1992) to estimates of 10 to 15 tree species per hectare with a dbh >25 cm (Wadsworth 1997). The actual distribution of tree species within the forest depends very much on

the species heterogeneity, described as species discontinuity across the forest landscape (Wadsworth 1997). In essence individuals of tree species of the tropical humid forests exhibit three main patterns of distribution, clumped, random and hyperdispersed. This gives forests dominated by one or a few species or at the other extreme very little repetition is found in species over an area (Terbourgh 1992).

1.3. Current threats to the humid tropical forests in the Neotropics

The main threats that cause forest loss in the neotropics are; infrastructure development (Hecht 1992, Carvalho *et al.* 2001) where roads develop in forest areas it increases the ease of accessibility to previously remote forest. Forest clearance is carried out by the poor landless for subsistence purposes or under policies that encourage large scale extensive agriculture such as cattle ranching (Hecht 1992) or through exploitative practices, such as illegal logging. In the 1970's policy in Brazil encouraged clearance of forests for agricultural development of cattle ranching. Currently a new economic development policy 'Advance Brazil' aims to develop large expanses of the Amazonian region. The major development is the planned highways to be constructed and secondly the policies to promote soybean cultivation, for export. It is expected if this goes ahead the increased accessibility to a remote region is the real threat to the forest cover (Cavalho *et al.* 2001, Nepstad *et al*. 2002).

Other threats that face the humid tropical forests in the neotropics is mining for minerals, often Amazonian is cited as the resource frontier due to the minerals that exist below ground and the timber above. Logging activities cause direct forest clearance, the classic 'fish bone' effect occurs around new roads and opened areas. Logging operations that concentrate on creaming forest timber species eventually

leads to habitat, species and genetic degradation of the targeted species. In Amazonian the most well known timber to suffer this fate is *Swietenia* commonly known as Mahogany (Hecht 1992). As a result of the high rates of exploitation and loss, the Brazilian government has made the harvesting and exporting of *Swietenia* illegal in order to attempt to halt the degradation of this genus.

Threats to forest loss in the neotropics are exacerbated as many of the countries are very poor and have weak positions within the global economy, being burdened with huge international debts and having little industry to earn foreign currency. The governments in the neotropics are under severe pressure to improve the economic situation and therefore the countries development for the benefit of the population. Most of the 17 million people who live in the Brazilian Amazon earn less than US$100 a month (Nepstad *et al.* 2002). A way for governments to realise quick capital is to use the natural resources; land, minerals, timber, in essence the forest.

These factors incorporated with the vast size and remote frontiers of Amazonia makes the task of governance of its resources and boarders expensive, compared with the many other problems faced by the population at large it becomes a low priority (Nepstad *et al.* 2002), this is reflected in the limited institutional and government capacity that is found in these regions (Nepstad *et al.* 2002).

1.4. Forest Policy Development

In the last twenty years there has been an increasing awareness of global changes in the atmosphere and land use, and their present and potential effects on the biotic and abiotic environment (Elliott *et al.* 2000). There have been important international

agreements that will have direct influence on the development of global and national forest policy, that will assist in shaping the future of forest management, restoration and creation of new forested areas. The international agreements with reference to forests are the 1992 Rio Declaration on Environment and Development, with the statement on Forest Principles, the United Nations Framework Convention on Climate Change known presently as the 1997 Kyoto protocol, and the Convention on Biological Diversity (Rio Earth summit 1992; Elliott *et al.* 2000).

The statement on forests, gives recognition to the fact that they are important in providing global benefits such as water and climate regulation and genetic resource stocks and also recognition of human dependence of these resources. It is widely accepted that forests should be managed sustainably to meet the social, economic, ecological, cultural and spiritual needs of present and future generations (Higman *et al.* 1999, Elliott *et al.* 2000). In light of the aforementioned threats (Section 1.3) that face the humid forests of neotropics there is a need to improve current forest practice, and address the forces that drive destruction within the field of forestry as far as is possible. Although the international agreements do try to address the political and poverty driven threats that face the forests this is needed, as technical forestry solutions alone will not solve the problem of forest loss.

1.5. Ecological management - sustainable forest management

The reason why ecological management has developed is due to the utilisation of some part of natural resources to benefit of ourselves. Weather it is a forest used for collecting fruits or harvesting timber, a savannah for grazing livestock or a river to supply fish, the system is managed so that it can provide at the maximum level the

resource required, but sustainable management must secure the continued production of the resource for the future.

Sustainable management involves the documenting of the resource, monitoring its use and its recovery after disturbance (use). This provides information that allows predictions to be made about its future productivity. Without some form of management or conscious thought about who and how the resources are utilized, it is likely that it will suffer from degradation and in turn decrease productivity as pressures on them increase.

1.6. Forest management for timber harvesting

To manage a neotropical humid forest sustainably in terms of timber production the silvicultural system that is most commonly employed is Reduced Impact Logging (RIL) using the principles of natural forest management to base decisions upon.

Sustainable forest management is managing the forest for one or more products through a system that will allow continued productivity but not cause irrevocable damage to the integrity or function of the ecosystem (Higmann *et al.* 1999). Management is needed so that a balance is found between the operations being economically viable and the harvesting system being ecologically and socially viable.

Chapter 2 –The Implications For Sustainable Forest Management and Timber Harvesting In a Species Diverse Forest; In focus the Humid Tropical Forests of the Neotropics.

2.1 What is Biodiversity?

Biodiversity is a jargon contraction of, biological diversity (Burley 2002), in essence biodiversity is a measure of the diversity across many scales (McNeely 2002). The three essential components that constitute biodiversity is, the number, variety and diversity of living organisms. These are measured as diversity in genetic material, variety in the number of taxonomically distinct species and variety in the landscape in terms of different ecosystems that exist (Burley 2002).

Forest are of paramount importance when considering species and genetic biodiversity, especially tropical rain forests. Although tropical rain forests cover only 7% of the worlds land surface they are thought to contain more than half of the species that currently exist on the planet (Wilson 1992). Considering the factors that threaten the loss and degradation of the rainforests in the neotropics (Chapter 2, 2.1) and the rate at which the processes of loss and degradation are occurring are cause for prominent international focus this is due to diversity that is contained within the neotropical humid forests this is why they have become areas of prominent international attention. The Convention on Biological Diversity in Rio 1992, outlined the importance of biological diversity and principles that should be considered for its protection. In essence protecting biodiversity is driven essentially by the lack of knowledge about species on the planet that potentially may have many uses; in medicine, improving agriculture, in industry or managing the landscape and natural resources better in the face of intensified use.

2.2 Biodiversity and sustainable timber extraction

For the practice sustainable of forestry there are many factors to be considered in order to 'measure' the success of the management. Most prevalent in current literature, government declarations and environmental mission statements is the biodiversity factor. In the forest operations of harvesting and extraction the biodiversity should remain intact as far is possible and not be degraded to a level were the integrity of the forest ecosystem is irreversibly damaged.

Where biodiversity constitutes part of the management plan for a forest, the first stage in the knowledge should be to investigate the ecosystem diversity that exists in the forest area, then to know what species are present in the forest. With this knowledge the best decisions can be made about what volume can be removed and of which species, so that the harvesting will have a minimum impact on the species composition and abundance. In the sustainable management of a forest, a strategy should be in place by which to assess the forest biodiversity and more importantly any changes that occur. This allows impacts of the logging on the forest to be analysed.

In tropical forests it is impractical to count every species this knowledge will not be available for many years to come in the future, if ever. Biodiversity then is redefined, it is not possible to quote it as a number of species present or the genetic diversity. It really then becomes a factor constructed to communicate the relative diversity of an ecosystems to a wider audience, such as governments and the public, so that the importance in preservation of ecosystems can be defined or prioritised. These

decisions need to be made due to the lack of resources that currently find their way to assisting forest and resource management.

Assessing biodiversity is cited in some current literature to be wasting valuable research resources as it is argued that research and resources should be directed towards the factors that are the causes of forest loss and degradation (Sheil 2002), to safeguard the habitat of forest resources. As degradation and habitat loss happen at quicker rates than it is possible to document biodiversity.

But if wider society or international agreements require this flagship issue as a measure of sustainable forest practice, methods have to develop that provide this indication of species diversity and number. Methods currently used for example, are indicator species such as beetles, their numbers are used as an estimation of the species diversity of a forest. Another method is to use forest structure and composition as an indication. Both these systems are largely on applicable in a research environment where there are people with specialist knowledge and budgets are available (given the economic climate in the neotropics) to carry out this work.

If measuring biodiversity gives and indication of good or bad forest practice then the only way that this will have an impact in the commercial logging sector is if the methods are applicable in the field and repeatable by no specialists.

2.3. Commercial forestry inventory practices; problems that exist with species identification in the timber industry

Given that there is still much to be learnt about the tree species and undoubtedly a great many number still to be described by science in the neotropical forests, one logical progression in sustainable forest management would be to improve the accuracy of the inventory. In terms of species identification. To provide a measure of biodiversity with more certainty, if that is what international standards require.

An accurate tree inventory will provide information on how tree biodiversity is changing within a forest, as in extraction, the individual is physically taken from the forest altering the population composition and potentially its future regeneration. Tree species identification is fundamental to all other research components, such as forest structure and dynamics, growth and yield or regeneration (Sist *et al.* 1998).

In the timber industry in the Amazon region of the neotropics, there are many problems that exist with the correct identification of trees. The sector does not currently have the capacity to identify many trees to the level of species (Kanashiro *et al.* 2002) either at the point of source or in the timber yards. It is common practice when a commerical inventory is conducted in a tropical rainforest that trees are identified using the common, local or market names. In this process many taxonomically different species are given the same name. For example a timber marketed in Brazil and internationally that has the common name 'Angelim' is known to apply to 32 taxanomically different species from 13 genera in Brazil alone (pers.com Regina Célia Viana Martins da Silva 2002, Kanashiro *et al.* 2002) In a

study at a logging yard in Brazil conducted by botanists they found that a timber load marketed as 'Louro amarelo', actually contained two species that were previously undescribed (Kanashiro *et al.* 2002). There will be inherent problems that arise from managing a forest under a sustainable forest system, if trees of commercial value are not able to be identified correctly.

2.4 The consequences for the forest by not identifying trees to species level.

2.4.1. Ecological integrity

Long term survival of a species depends on the evolutionary potential of the population, successful biodiversity conservation is achieved by the maintenance of reasonable levels of genetic variation within a population and the conservation of the ecological and genetic processes that support that genetic make-up (Namkoong *et al.* 2002; in Kanashiro *et al.* 2002). The removal of species from the forest categorised under vernacular or local names could accidentally remove all rare individuals of a species confused by one or more common names (Project Dendrogene 2002). This problem of not being able to identify with certainty what leaves the forest, could potentially create more problems for the timber industry and the organisations that support sustainable forest management.

2.4.2. Communication of forestry practices through international organisations

Sustainable forest management is currently the best silvicultural system that exists for harvesting in tropical forests and it is accepted by wider society as 'good' forestry. This type of forestry relies heavily on support and maintaining a reliable tract with the public. Although such organisations as the Forestry Stewardship Council (FSC) supported by global organisations like the World Wildlife fund, both fully endorse

and promote sustainable forest management, (based on a set of prescriptive criteria and indicators) the FSC is a progressive organisation that works with the industry to achieve targets and does not expect concession owners to change all their forest practices in one fell swoop (as it is unrealistic). It is though interesting that the FSC in criteria and indicators they do not cite this problem of commercial tree species mis-identification, which is a fundamental step in the operations that will conflict directly with working towards sustainable forest practice.

Not identifying trees to species level the potential problem then arises of communication with a wider audience of people; To manage a forest sustainably and not even guarantee to know the species of trees that you are removing from a forest site, it is foreseeable that people may lose faith in 'sustainable forest management'. The environmental lobby groups will want to know how decisions are made about harvesting and therefore biodiversity implications, if the forester cannot guarantee that they know every species of tree that is cut. The suspicion will further be confirmed if there is no system in place within the management to account for these unknown or rare species. Not including guidelines on basic inventory practice and setting systems in place for improving the companies capacity for better species identification seems to be a high risk to take, especially due to the distrust that already exists between the industry and their main critique's, environmental groups and the public. Species that leave the forest as cut timber is such a fundamental point to the harvesting and operating systems and future impact on the forest that it really has to be given more attention in sustainable forest management.

2.5. The consequences for the timber trade by not improving identification of commercially important trees

Correct identification to species level will ultimately save time and money in the harvesting, by only removing the species being removed from the forest that the client wants or there is a market for. Problems occur on both sides of the trade, (buyers and sellers) when there is inconsistent use of names applied to timber. For instance a timber importer in Germany wanted to buy more 'Cedrinho'. The supplier from southern Brazil had been supplied from the lower Amazon and was informed that this timber was difficult to obtain. If the timber had been identified by both parties as *Erisma uncinatum*, its scientific name, the exporter would probably have been able to find out that large volumes were available in the Eastern Amazon, where it is commonly known as 'quarubarana'(Kanashiro *et al.* 2002)

2.6. Why common names are used in the inventory

These names are used in a commercial timber inventory for a variety of reasons, firstly local names are used as obviously they are familiar and are culturally an integral part of wider society that local people working in forestry will have some knowledge of. Secondly these common or market names, are usually what employees learn to identify certain trees by when they start working with a team (Pers. Com. Williiam Hawthorn, 2002). Thirdly common and market names are much easier to learn and use compared with scientific names, and the information is usually available locally compared with sources for scientific names. If many species are yet undescribed by science a name is still needed in the mean time that people and companies can apply to identify the tree to them meaningfully.

Many different trees being identified by the same market name in a traditional logging operation reflects the fact that many taxonomically different species will have similar wood properties in terms of the product they go on to be. For logging operations, woods of similar market use will be grouped together making the organisation and transporting a much simpler operation at the landing point.

2.7 Potential for training inventory teams in the of use a scientific names

Inventory teams in a commercial environment are usually under pressure to complete the inventory process as quick as possible, so that the whole logging operation can be justified economically. Identification is commonly done using the characteristics at eye level such as the bark, timber colour, bole characteristics and latex. Differences between taxonomically distinct species can be subtle and difficult to differentiate when only using the bole characteristics. But thiss a practical method in a commercial situation,it is quick (ut inaccurate in determining to species level). Climbing trees to collect material for identification of the leaves, is to time consuming an activity in this environment, it will be expensive to buy the safety equipment required and to dangerous to do day after day if no safety equipment was provided, and ultimately identifying to species level requires specialist knowledge of botany, money would be needed for training increasing the operating costs again.

The forestry sector is notorious for working conditions being dangerous, with a high risk of injury or death, the job sector is insecure and underpaid (Higmann *et al.* 2002). Sustainable management is not possible without a workforce, they must be motivated to work efficiently towards the principles of sustainable forest mangement, as they are also stakeholders in the process. There work will ultimately determine the success

of the operations in meeting the required management objectives, (Higmann *et al.* 2002) therefore systems related to working conditions must be set in place as an important component in achieving sustainable forest management.

2.8. Training in the inventory

It would not be institutionally too distant within a timber harvesting and extraction company. As to use an inventory for the basis for an indication of diversity an inventory will be usually be carried out in commercial logging. This is more applicable than say asking people to count beetles or birds. Inventory workers will already have a background in tree identification, so building on these skills, would hopefully be more acceptable within this working environment.

2.9. The need for communication in forestry

Using local names may only reflect how a species is known and identified in a small area or region. By using a Latin name to identify a plant makes the information about the forest far easier to communicate to a wider audience, be that government, the timber trade or environmental groups.

Latin names are linked to one distinct species only, whereas with local names some species don't have names, the same local name applies to more than one species or there may be more than one local name that applies to the same species (Stockdale 1999). A Latin name helps to clarify the species actually present and this is important information that needs to be communicated if the concession is to be accepted to a wider community that it is managed sustainably.

2.10. Marketing of The Timber

Correctly identifying species could potentially help to improve how the product is marketed and sold. Having knowledge of the wood properties to species level can ensure that those grouped together in the forest landing are most alike in similar properties as required by the buyer.

This is important if the buyer applies a mechanical process to the drying of the timber in a kiln. The properties need to be very similar so that the timber can be dried efficiently in a mechanical kiln.

For example this year at Timbmet, (Oxford) a shipment of Makore was received from Ghana, it was supposed to be the same timber. But what was actually found was that there was great diversity of species within the delivered load timber. Most of the timber was put to waste as it was to expensive to sort it and kiln dry each bundle of different wood. The contract with the company was hence terminated (pers. com. Benedicte Masson, 2002).

There are several possibilities that could have lead to this situation that are not directly related to the point of harvest such as mixture of wood in the timber yard or port. But this example does highlight the fact that it is important that timber of similar properties are grouped together and that it is an important fact to know what you have for sale , who you are selling to and its related properties.

2.11. Problems With Identifying to Species Level

The differences between closely related species often has to be determined by looking at another characteristic that are not at eye level, for example leaf morphology, petioles or branching patterns, are some obvious characteristics to look at.

It is desirable that identification characteristics are based on features that are likely to be easily available. Although flowers can sometimes be distinctive to a species, it is highly unlikely that there phenology patterns will coincide with the time of the inventory. It is far more reliable to base the characteristic feature on something that has longevity i.e. leaf structure, leaflet morphology or a characteristic such as a glands, petioles, leaflet shape or veination.

There are many problems associated with identification to species level, first specialist knowledge is required for the identification process. To gain an accurate identification material must be obtained from the canopy, (as it is not reliable to rely on leaves that have fallen on the ground below the tree). Correct identifications can also be made by skilled individuals using binoculars which negates the need for access to the canopy.

There is still much work that needs to be done in describing tropical timber trees, in order that species within common name groups can be identified from each other. Guides to identification need to be applicable in a field situation and especially with regards to commercial timber harvesting they have to be applicable in the situation of an inventory team who are expected to be efficient and cover many hectares in a short period of time.

2.12. Limitations in the commercial sector for attaining species level knowledge

But this can take a considerable amount of time again in the inventory process this procedure would slow the team down, or it would require extra people to be hired or trained that had more skill in identifying canopy features, adding extra costs to the process.

But this process is also time consuming in comparison to bole identification. Binoculars would need to be of a high quality to give good resolution to the use to pick out small features that are potentially 20 to 25m up in the air and against the background of a bright sky. This again adds extra cost to the operations.

2.13. The reason to work towards species level identification

Knowing the scientific name of the trees greatly improves the ability to communicate information about a species to an outsider i.e. the timber company and governement (Stockdale 1999). To attain sustainable forest management the only way to protect the genetic diversity and ecological integrity of the forest is to start to working towards identifying to species level and finding a way to make the system applicable in commercial sector. Although sustainable forest practices try to compensate the loss of an individual and disturbance to the forest ecosystem, due to the life span of trees we will not be around to analysis the results of the decisions that were made in the forest. In order that the field of forest management becomes stronger and based more on evidence rather than estimations it requires us to record as much information about a system at present. before it is changed so that the information is available to the forests in the future to interrupt of actions of today.

Accurate inventories save time and money and can improve the planning of the overall harvesting in time and space. Knowing all tree species present, gives the forest mangers information to work on in the future if certain markets become developed for timbers that are currently not bought. The inventory done the first time accurately allows for better planning.

If species can be better identified at source this might help the timber market to have more information to market properly in terms of properties and also as environmental accountability trends for natural resources continues to be popular with public and wider society, naming of timbers correctly will help the importer or buyer to give more information so that people can know were there timber came from. People could start to practice ethical buying patterns with there wood products.

Chapter 3 – Botanical Classifiction and Description of *Dipteryx odorata* (Aubl.) Willd.

3.1. Naming and History *Dipteryx odorata* (Aubl.) Willd.

Dipteryx odorata (Aubl.) Willd. (synonyms: *Coumarouna odorata* Aubl., *Dipteryx tetraphylla* (Spruce ex Benth) Taub., *Cumaruna tetraphylla* (Spruce ex Benth) Kuntze, *Dipteryx micrantha* Harms, *Baryosma tongo* Gaertn. and *Dipteryx odorata* var. *tetraphylla* (Spruce ex Benth.) Ducke.) is the focus of the following chapter.

Dipteryx odorata was first described in 1775 by Jean Baptiste Christophore Fusée Aublet, as *Coumarouna odorata* Aubl., but *Coumarouna* was considered a synonym in 1791 of *Baryosma tongo* Gaertn. by Joseph Gaertner. In 1802, *Coumarouna* was moved into the genus *Dipteryx* (also spelt *Dipterix*; Pyramo de Candolle 1825, Lindley 1846) as *Dipteryx odorata* (Aubl.) Willd. by Carl Ludwig von Willdenow. In 1860, George Bentham described *Coumarouna tetraphylla* Spruce ex Bentham. In 1891, Paul Hermann Wilhelm Taubert placed *Coumarouna tetraphylla* into the genus *Dipteryx* as *Dipteryx tetraphylla* (Spruce ex Benth) Taub. In 1891, Karl Ernst Otto Kuntze changed the spelling of *Cumarouna tetraphylla* to *Cumaruna tetraphylla* (Spruce ex Benth.) Kuntze. In 1925 Adolfo Ducke recognised *Dipteryx tetraphylla* as a variety of *Dipteryx odorata, Diptreyx odorata* var. *tetraphylla* (Spruce ex Benth.) Ducke. In 1926, Hermann August Theodor Harms recognised another species of *Dipteryx* as *Dipteryx micrantha* (Harms).

The genus *Dipteryx* (synonym *Coumarouna*) was described by Johann Christian Daniel von Scherberin in 1791. The genus was first placed into synonymy in 1777 as *Heinzia* by Joannes Antonius Scopoli and also in 1790 as *Bolducia* by Noel Martin Joseph Necker. *Dipteryx* was placed into synonym for the third time in 1965 as *Oleiocarpon* by Pittier Dwyer.

When Schreber named the genus *Dipteryx, Coumarouna* and *Taralea* were combined (Ducke 1940), due to the resemblance of the flowers, although the fruits were distinctly different. *Coumarouna* has drupaceous (the pericarp is fleshy or leathery, containing a stone with a kernal) and indehiscent (fruits do not open at maturity) fruits, whereas *Taralea* fruits are bivalvate (fruit capsule with two halves) and elastically dehiscent (opening when the seeds can no longer be contained inside the fruit body) pods (Ducke 1940). *Taralea* Aubl. was rejected as a synonym for *Dipteryx* and is a distinct genus (Missouri Botanical Gardens 2002)

In the genus *Dipteryx* there are 54 names recorded, 58 names in the genus *Coumarouna,* nine names in the genus *Cumaruna,* two names in the genera of *Baryosma* and *Heinzia* and one name in the genus *Bolducia* (IPNI 2002).

3.2. The Family and Tribe of *Dipteryx odorata*

Dipteryx odorata is a member of the family *Fabaceae* (synonym *Leguminoseae),* and it is placed in the subfamily *Papilionoideae. Dipteryx odorata* belongs to the neotropical tribe *Dipteryxeae* (synonym *Dipterygeae*) the tribe; contains two other genera, *Taralea* Aubl. and *Pterodon* Vogel (Polhill *et al.* 1981, Lewis *et al.* 2000).

Fabaceae is one of the largest flowering plant families with some 18,000 species classified into 650 genera (Polhill *et al.* 1981), with subfamily *Papilionoideae* being the largest of the three subfamilies, containing some 12,000 species in 440 genera. Subfamily *Papilionoideae* is widely distributed from rainforests, to the edges of the dry and cold deserts (Polhill *et al.* 1981, ILDIS 2002), and is found in Australia, tropical Asia, the Mediterranean, the Cape, the Gulf of Guinea and North America. The main diversity in growth form and systematic composition occurs on the Planalto of Brazil, the Mexico region, eastern Africa, Madagascar and the Sino-Himalayan region (Polhill *et al.* 1981). The principal areas in which the rainforest trees and lianes of the *Papilionoideae* are found, is in the Amazonia and the Gulf of Guinea (Polhill *et al.* 1981).

Members of the subfamily *Papilionoideae* are recognised by their *papilionaceous,* butterfly-like flowers. The flower is irregular (zygomorphic) and is made up of five petals; a standard petal (vexillum), two wing petals (alas) and two petals partially fused together form a boat-shaped structure, the keel (carina) (ILDIS 2002). The essential family features are: the flower with a calyx-tube, the adaxial (next to the axis) petal outside when in bud and the anthers, that become petaloid (resembling a petal) to signal insect-visitors (forming a flag) at the time of pollen release (anthesis). The last characteristic feature of the family is that the ferile parts are contained inside the keel (Polhill *et al.* 1981, ILDIS 2002)

3.3. Description of the Genus *Dipteryx*

3.3.1. Leaves

Leaves are paripinnate, i.e., the leaf ends with a pair of leaflets (Macbride, 1943) and the leaf rachis and petiole are winged, with the leaf terminating in a winged extension (Lewis *et al.* 2000); with small appendages (stipules) on each side of the leaf at the base of the leaf-stalk intersection (Loureiro *et al.*1968).

3.3.2. Leaflets

Leaflets are arranged alternately (Macbride 1943), leathery (coriaceous) in nature and have no stipules (appendages of a leaf on each side of the leaf-insertion) (Macbride 1943). Sometimes leaves are wholly or partially transparent (pellucid) marked with dots, depressions or translucent glands (punctate) (Macbride 1943). Sometimes leaflets are without any transparent (pellucid) marked dots, depressions or translucent glands (punctate) present (Ducke 1940). Some leaves of this genus can be long-lived and the leaflets attract many gall formers and fungal diseases (pers.com Mike Hopkins 2002), which form spots and patches on the leaf surface that can be quickly recognised (Ribeiro *et al.* 1999).

3.3.3. Flowers

Flowers range in structure from, the petals having a notch cut out at the tip (emarginate) nearest the inflorescence stalk (stipe) to where the flower is divided half-way (bifid) (Macbride 1943). Petals are coloured rose and partly whitish (Ducke 1940).

The infloresence (cluster of flowers) is a loose cluster, as a branched raceme or corymb (paniculate) (Pyramo de Candolle 1825). The inflorescence branches are rather elongated and are relatively loose (laxiflorous), even before the expansion of the flowers at the time of pollen release (anthesis); bracteoles much shorter than the adult flower bud (Ducke 1940).

The separate structures, the sepals which make up the calyx (a cup-shape structure enveloped around the flower; Jackson 1928) are rarely united (Macbride 1943). The calyx is composed of 3-5 sepals fused at the base, they form dome shaped structure that terminates in a small point (turbinate tube; Pyramo de Candolle 1825). The caylx rarely forms an extended tube at the top, only a small point (Macbride 1943).

Of the calyx, two of the upper lobes (sepals) are clearly visible (Pyramo de Candolle 1825, Macbride 1943), and larger than the rest, they are arranged subopposite ly and are wing-shaped (aliform) (Pyramo de Candolle 1825), they resemble petals (are petaloid) (Macbride 1943), the remaining sepals (ranging from 1 to 3 in number) are smaller and lower in the calyx structure (Pyramo de Candolle 1825, Macbirde 1943). The lower lobes of the calyx have small teeth (Ducke 1940).

The calyx is leathery in nature (coriaceous), it is more or less densely pubescent, covered with matted wool or short hairs (tomentous). On it are hidden glands (Ducke 1940), or glands that are translucent and appear as dots or depressions on the surface (punctate) (Macbride 1943). The calyx is often not green (coloured; Macbride 1943)

The ovary of the flower is smooth and without pubescence (glabrous) (Ducke 1940, Macbride 1943) but sometimes, although rarely, the ovary can have soft and distinct hairs (Macbride 1943); the ovaries have short stalks (from calyx to ovary base; Ducke 1940) which are narrow or tapered towards the base (Macbride 1943). The style is directed upwards (Pyramo de Candolle 1825).

There are 8 to 10 alternate stamens (Pyramo de Candolle 1825); alternate anthers are smaller and aborted (Macbride 1943), the anthers are united by their filaments.

3.3.4. Fruits

The fruit is typically drupaceous (Ducke 1940, Macbride 1943, Lewis *et al.*2000), it is sub-compressed and thick (Pyramo de Candolle 1825). The mature fruit does not release its seed by opening along a regular lines or valves (Macbride 1943).

The fruit is composed of two halves which have a cavity or valve (bivalved) structure on the inside of each half, they unite to form a capsule structure (locule) inside the fruit, which contains one seed (Pyramo de Candolle 1825).

The fruit is oily and the fleshy wall enclosing the seed has an aromatic smell; the fleshy part of the fruit is bitter and inedible by man (Ducke 1940).

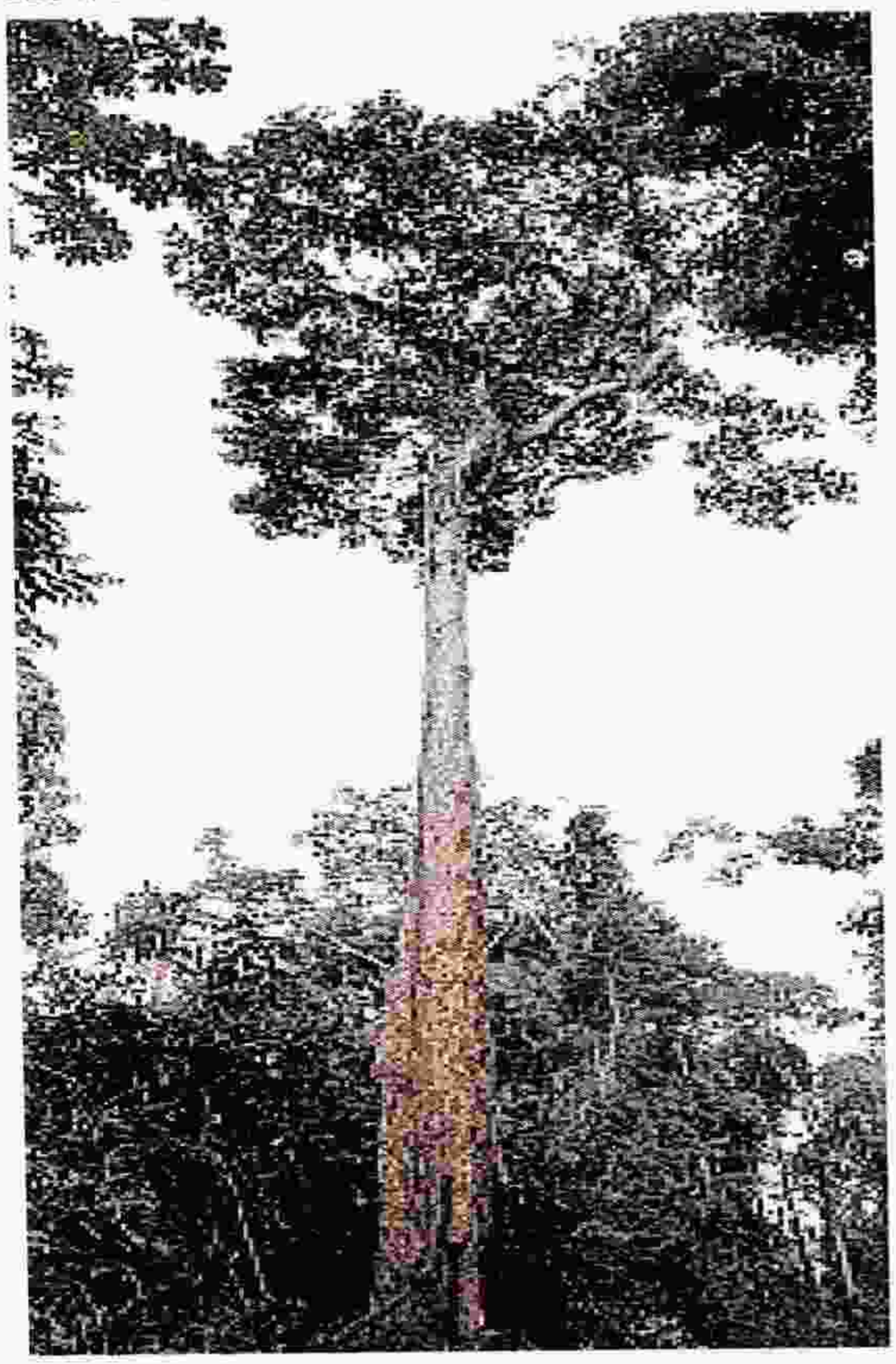
3.3.5. Seeds

The seed is ovate-oblong in shape (shaped like the longitudinal section of a hen's egg), also described as cylindrical fusiform (Lewis *et al.* 2000). The seed has a terminal radicle (Lewis *et al.* 2000). The seed hangs like a pendant in the fruit cavity

and there is no endosperm present (Pyramo de Candolle 1825). The embryo of the seed is straight and the first leaves produced (cotyledons) are thick (Pyramo de Candolle 1825). The seed is odorous and rich in an extractive called coumarin (Ducke 1940).

3.4. Species Description of *Dipteryx odorata*

Fig. 3.4.1. *Dipteryx odorata* tree, with a straight bole and slight buttress formations. However these are not true butressess.



(Madeireira Gumimarães 2002, no scale avaliable)

3.4.1. The Tree

Dipteryx odorata reaches 30 m or more in height (Ducke 1940, Brown 1977, Chudnoff 1984, Azevedo *et al.* 1999) and has been described by others as a canopy tree or an emergent (Fanshawe 1948, Parrotta *et al.* 1995, Ribeiro *et al.* 1999). The tree is unbuttressed and the bole is clear and cylindrical (Fanshawe 1948, Brown 1977, 1978, Berni 1979, Chudnoff 1984). Loureiro *et al.*(1968) although contradicts this statement, stating that *D. odorata* has buttresses up to 1 m in height. The tree has a heavy, rounded crown (Fanshawe 1948). The bole length ranges from 18 to 24 (Fanshawe 1948, Hess *et al.* 1950, Brown 1977, 1978, Chudnoff 1984), with the bole being clear up to 18 m (Hess *et al.* 1950, Loureiro *et al.* 1968, Chudnoff 1984). Recorded trunk diameters range from 0.5 m to 1 m across Figure 3.4.2. (Hess *et al.* 1950, Brown 1977,1978, Chudnoff 1984).

3.4.2. Bark

Dipteryx odorata has been described as having bark that is yellowish-brown in colour (Ducke 1940, Macbride 1943, Loureiro *et al.*1968) or as in the 'Reserva Ducke' near Manuas the bark is recorded as dark grey-yellow Figure 3.4.3. (Ribeiro *et al.* 1999). The bark, at breast height, is described as hard and smooth but scaly (Ducke 1940, Macbride 1943). In old trees, the bark is characterised by having large irregular plates (Loureiro *et al.*1968, Parrotta *et al.* 1995). The bark and sapwood of the stem and branches have pea-like smell (characteristic of many *Fabaceae*; Ducke 1940).

Fig. 3.4.2. Trunk of mature *Dipteryx Odorata* tree showing bark colour, and irregular plate structure of bark and lower bole shape.



(Parrotta *et al.* 1995, no scale available)

Fig. 3.4.3. Close up of bark of *Dipteryx odorata,* showing variation in bark colour, slash mark showing colour of sapwood.



(Parrotta *et al.* 1995, no scale avaliable)

3.4.4. Leaves

Leaves are compound and paripinnate, the leaf terminating with a pair of leaflets (Ducke 1940), the leaves are arranged alternately and are approximately 25-26 cm in length (Specimens of Daubeny Herbarium, Oxford University 2002); they are composed of 4 to 6 leaflets on fertile branches (Pyramo de Candolle 1825, Ducke 1940, Macbride 1943, Loureiro *et al.* 1968), and can number 8 leaflets on a sterile branches or young shoots (Ducke 1940, Macbride 1943). The leaf rachis (axis of a compound leaf) and petiole (the foot stalk of the leaf) are winged, with the leaf terminating in a winged extension (Pyramo de Candolle 1825, Ducke 1940 Macbride 1943, Loureiro *et al.*1968, Lewis *et al.* 2000); the petiole (foot stalk of the leaf) has a compressed stem (Pyramo de Candolle 1825, Ribeiro *et al.* 1999).

Fig. 3.4.4. Leaf showing arrangement of leaflets; sub-opposite, the solitary leaflet showing underside colour, a complete fruit and fruit opened containing the seed.
(Parrotta *et al.*1995, no scale available)

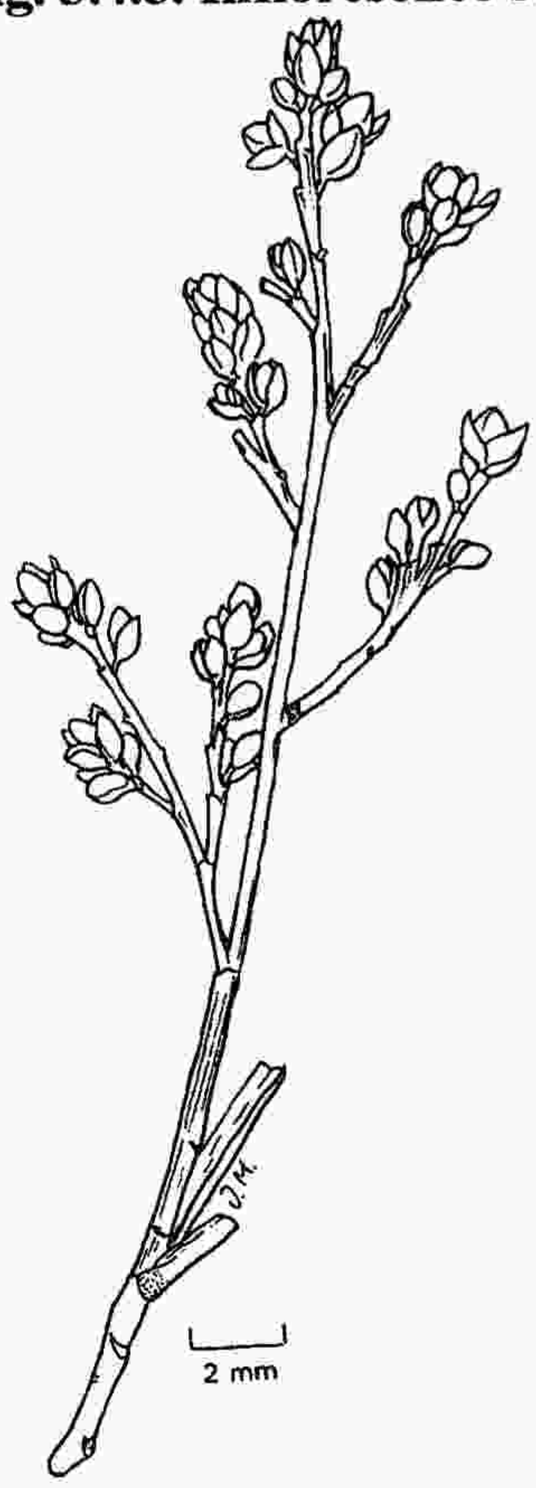


3.4.5. Leaflets

The leaflets are sub-opposite or alternate in arrangement; (Figure 3.4.4.) (Pyramo de Candolle 1825, Loureiro *et al.*1968). The leaflets are oblong in shape and commonly 10-15 cm in length (Macbride 1943, Loureiro *et al.* 1968, Ribeiro *et al.* 1999) and 4 to 6 cm in width. The terminal end of the leaflet gradually diminishes into a

point (Macbride 1943, Loureiro *et al.*1968), and the base of the leaflets is rounded and unequal (Specimen Duabeny Herbarium, Oxford University 2002). The leaflets are semi-coriaceous to coriaceous (leathery), they are smooth and without pubescence on their surfaces (Macbride 1943, Loureiro *et al.*1968). The leaflets can have glands present on their surfaces (glandular, possibly as a result of gall formers or fungal diseases pers.com. Mike Hopkins 2002), the leaflets are not transparent or marked with dots, depressions or translucent glands (pellucid-punctate; Macbride 1943). The leaflet has a small petiole with a winged margin (Pyramo de Candolle 1825, Loureiro *et al.*1968).

Fig. 3.4.5. Infloresence structure

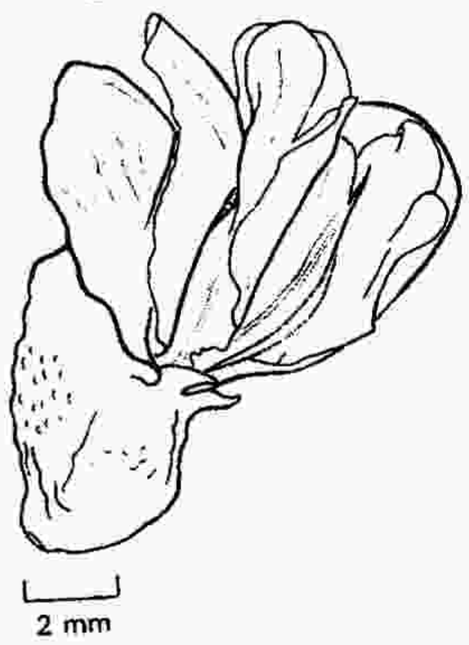


(Spichiger *et al.*1989)

3.4.6. Flower

The inflorescence is a short terminal panicle (a branched raceme, with each branch bearing a further raceme) of flowers; Macbride 1943, Loureiro *et al.*1968).

Fig.3.4.6. Flower

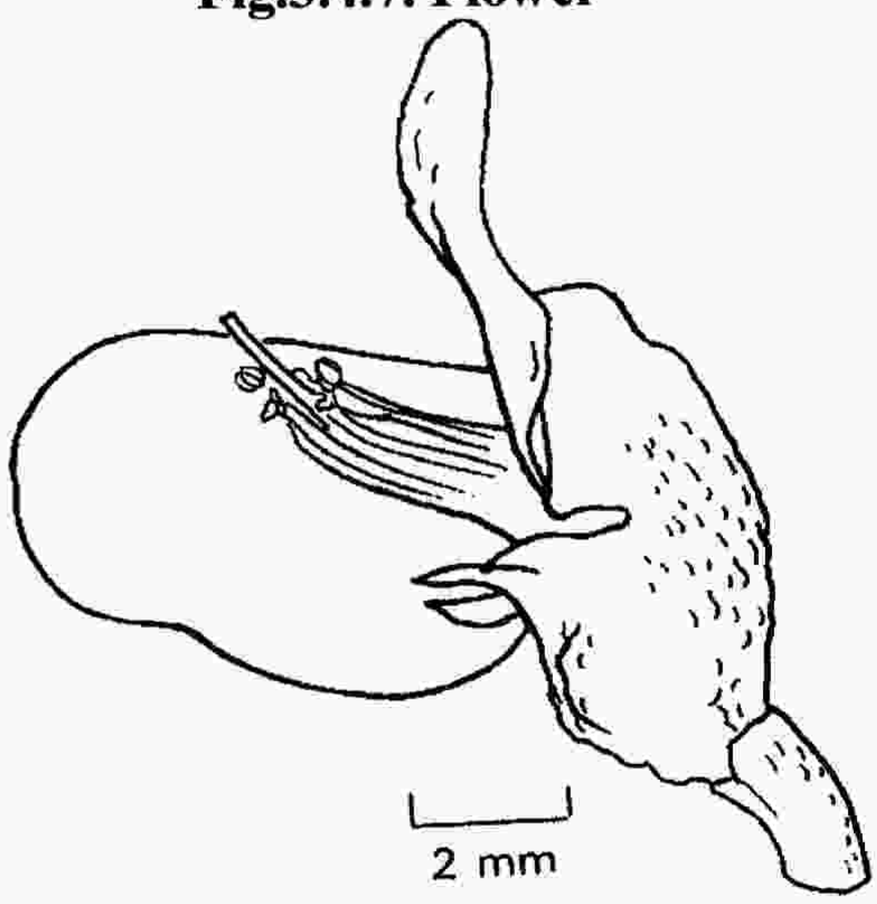


In colour, the banner of the flower is whitish with the rest of the flower being rose (Macbride 1943) although Loureiro *et al.* (1968) describes the flower as whitish **(Spichiger *et al.* 1989)** and the wings later developing (post pollination) to a rosy-purple to crimson colour. The wings on the flower are notched at the extremity of the petal, the keel is straight and oblong (Loureiro *et al.*1968). The flowers are approximately 10 – 12 mm in length (Ducke 1940, Macbride 1943).

The calyx is bell-shaped (Loureiro *et al.*1968), the wings of the calyx are 10 – 12 mm in length, densely and uniformly covered with rust-coloured matted woolly or short hairs (Ducke 1940, Macbride 1943, Loureiro *et al.*1968). The calyx is heavily divided (laciniate) (Pyramo de Candolle 1825), with free and leathery upper lobes (sepals) (Macbride 1943, Loureiro *et al.*1968), the lower lobes are single (Pyramo de Candolle 1825). The calyx has three lower lobes, they are rudimentary and winged and have short tooth at the end of the lobes (Macbride 1943, Louriero *et al.*1968). The lower three lobes are bent back on themselves and at the end of the lobes they are eventually split into two at the apex (Loureiro *et al.*1968).

The ovary is linear, smooth and without pubescence (Macbride 1943, Loureiro *et al.*1968). There is one style with terminal stigma (Loureiro 1 *et al.*968). In the flower, 10 stamens are present (Pyramo de Candolle 1825, Loureiro 1968), the filaments of the stamens are united with anthers free to move. The ovule commonly has 5 fertile ovaries and 5 sterile ovaries, (Loureiro *et al.*1968).

Fig.3.4.7. Flower



(Spichiger *et al.* 1989)

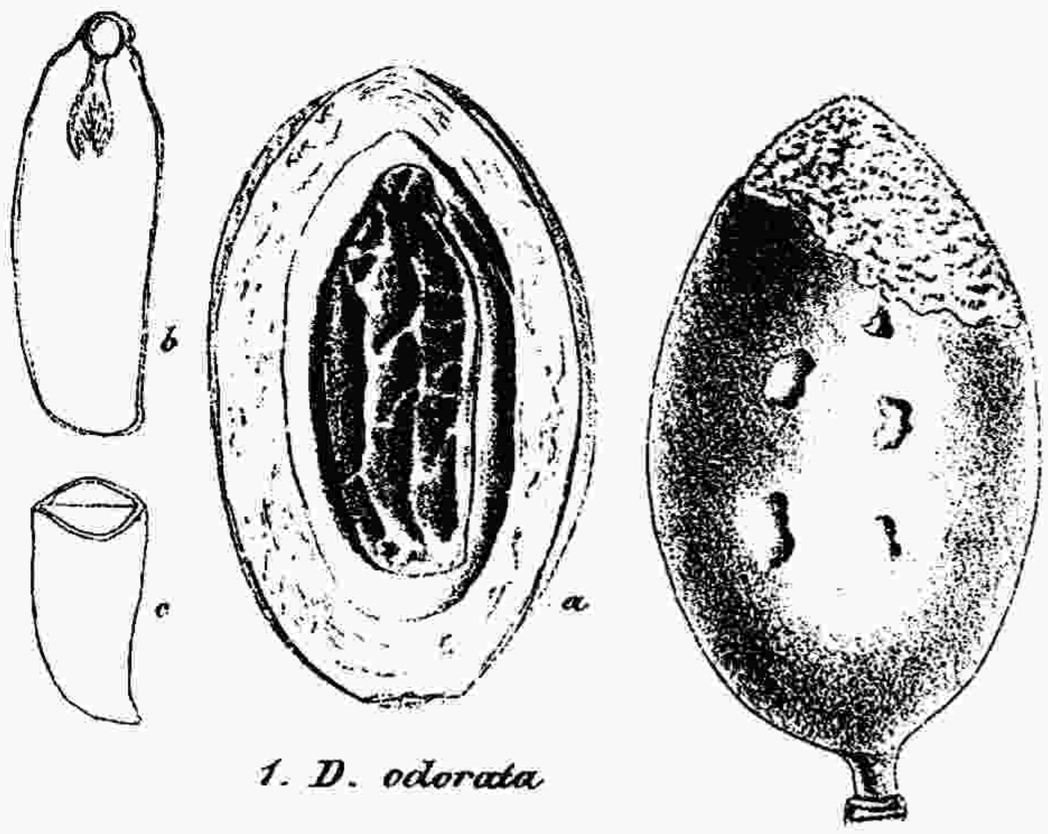


Fig.3.4.8. The fruit (far right), a; cross-section of the fruit with seed present, b; longitudinal cross section of the seed, c; traverse cross section of seed.
(Ralph 1849, no scale available)

3.4.7. Fruits

The fruit is drupaceous, the pericarp is thick, oily and aromatic (Macbride 1943, Loureiro *et al*.1968) the endocarp is woody, ovoid and oblong in shape, approximately 5 cm in length and 3 cm in diameter.

3.4.8. Seeds

The seeds are oblong in shape, they are bitter and not edible to man, they are aromatic, and were extracted they produce an essential or industrial oil containing coumarin (Loureiro *et al*.1968).

Chapter 4– Evidence to Support the Distribution of *Dipteryx odorata*

4.1. Distribution of plant populations

Determination of the natural range of a plant species is difficult since natural and anthropogenic factors will influence how a plant population will grow and how an area will be colonised. Natural factors, such as rainfall, temperature, light and soil, can help to define boundaries of ecosystems and therefore give an indication of where species are likely to be found. Over time, as natural factors vary, they will influence the distribution of a species. For example, climate change may favour certain species to colonise new regions and hence increase its range. Conversely, other species may go in to decline and its range becomes reduced. Ultimately, species survival in a changing environment depends on the ability to adapt, evolve and cope with environmental changes, natural or anthropogenic.

Plants that are useful for humans will undoubtedly have their ranges extended beyond the area where it originated, through the processes of cultivation and domestication. Domestication and cultivation of plants occurs at a local scale, within communities of people who live in or near forests. Many plants are taken from the forest and are cultivated close to homes or used to enrichment plant certain areas in the forest or surrounding landscapes.

4.2. History of the Kayapó Indians in the Brazilian Amazon Basin and their forest management systems

The Kayapó Indians from Brazil have a complex system of ecological management to enrich there surroundings with useful plant and animal organisms. They create areas that are planted with useful species that provide food, medicine, ceremonial items firewood and materials of daily use (e.g. baskets, needles, insect repellents). The Kayapó plant useful species through a variety of management systems, they will plant in clearings in the forest created by natural tree fall, or will create an opening by felling of a tree. Species are also planted in 'forest islands', (these are areas that are cultivated in the *campo* (savannah scrub) with useful species, hill gardens are created for reserves in times of flooding or crop failure, forest trails are enrichment planted with useful species and naturally people cultivate and maintain areas close to the house (Posey 1985). For example, it was found that of 140 species collected in a 'forest islands', only two species were not considered useful by the Kayapó Indians – indicating the existence of 138 useful species is not a coincidence.

In the pre-colonial era of Brazil, the population of indigenous people was denser than at present. Therefore, it is likely that many areas of Amazonian forest that were once thought of as 'natural', have in fact been altered or cultivated to provide areas enriched with useful products. For example, the extent of trails associated with one Kayapó village (Gorotire) is estimated at a total distance of 500 km (Posey 1985), these paths are used by communities to travel. For instance, the Kayapó still carry out treks lasting several months. For an entire community, food gathering cannot be left to chance in the forest, hence, the practice of enrichment planting along trails and in forest clearings has developed (Posey 1985). In the Amazon region the presence of indigenous people stretches back millennia, as will their history and development of

resource utilisation, thus it is highly likely that human impact on the forest is widespread.

Due to the practices of indigenous resource management, such as those practised by the Kayapó Indians, it makes determining the 'natural' range of a species, extremely difficult. These difficulties are compounded when a species is useful to man and the intimate knowledge of the historical distribution of people, their movements and use of the resources is largely unknown. The history of the people of the Amazonian region is currently not well understood as compared with that of other civilizations such as the Incas or the Mayas. Temples and city structures are obvious archaeological artefacts that exist for these other civilizations making them a root source of information about the cultures of the Incas and Mayas.

The people of the Amazon region appear to have not constructed such permanent structures. Their history is perhaps provided by evidence that until recent times was not well understood. Indications to the history of the Amazonian people is in found in 'ecological artefacts', such as searching for Brazil nut or palm groves that occur within the forest that indicate cultivation and settlement. A species of trees can be found to occur at unusually high densities dominating the forest areas, giving an indication of deliberate planting or enrichment activities. Another ecological clue is the *terra preta* (black earth), these are areas of soil that are very fertile and have a composition that suggests composting activities. These areas are believed to have been created by pre-contact indigenous settlements (Mann 2002). The cultures of this region generally do not have a history of written language, but an oral tradition, with

the colonisation of the region by Europeans much of this knowledge has be lost or degraded as many cultures were destroyed.

4.3. Ethnobotanical Classification

Where plants provide a useful resource to humans a linguistic relationship of naming and classification will begin to evolve.

There are two main theories as to how names for plants come into existence, the utilitarian approach in ethnobotany suggests that societies residing in local habitats exhibit a system of ethnobotanical classification for a smaller proportion of the plant and animal species found in the same area (Berlin 1992). This indicates that people only develop names for plants that are useful to them, commonly plants yielding food, medicine or that have a cultural or spiritual importance to them and their community (Schultes *et al.*1995). In Britain for example there are many common names associated with trees, flowers and birds but they are few in number for such organisms as mosses or fungi which rarely have a use in Britain. For example here we have many flowers that fall into this category, Red campion, milkwort, ragwort but to name a few.

The second approach to how people form classification systems for the organisms around them is thought to based primarily on the idea that people observe morphological and behavioural affinities and differences among recognised taxa (Berlin 1992). This theory suggests that cultures will name organisms that do not necessarily provide a functional use to them other than perhaps an aesthetic value.

4.4. Correlation of common or trade name groups with countries

There are certain groupings of particular common names related to *Dipteryx odorata,* that show their existence is related to a certain geographical regions. For example, the name Cumaru is used either by itself or as a prefix to other names (29 names in total). Of the names that exist, including Cumaru, 76% were from Brazil and with four other countries bordering Brazil: Bolivia, Venezuela, Guyana and French Guiana. Hence, there will be a merging of information between people on borders to a certain degree. Sarrapia appears 14 times in the list of common names associated with Venezuela and Colombia, but is only recorded again once in French Guiana and Guyana.

4.5. Distribution of *Dipteryx odorata*

From a review of the literature, the presence of *Dipteryx odorata* in various countries has been recorded, either as naturally occurring or cultivated. However as previously discussed, the concept of describing where a species occurs naturally or is cultivated is complex.

The species is cited to occur naturally in French Guiana, Guyana, Colombia, Venezuela, the Amazon region of Brazil, and northern Bolivia (Hess *et al*. 1950, Wangaard *et al*. 1952, Nakano *et al.* 1970, Brown 1977, 1978, Chudnoff 1984, Pesce 1985, Rico 1988).

Dipteryx odorata is thought to range from the forests of Honduras through Central America (Kribs 1968, Prance *et al*., 1975, Chichigound *et al.* 2001) into the Amazon region reaching eastern Peru to South-eastern Brazil (Lamb 1962).

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The seeds of *Dipteryx odorata* have had commercial importance in the last century as they are rich in an extract called coumarin, which is used in many different industries. Coumarin is the principal reason why there has been widespread cultivation of this forest tree in recent history. According to Brown (1978), *Dipteryx odorata* has been widely cultivated in Mexico and the West Indies, particularly in Jamaica, for the production of seeds. It has also been widely cultivated around the city of Manaus, in the State of Amazonas (Ducke 1940). Currently, Venezuela and Nigeria are the main producing countries for the seeds (Spice Pages 2002).

From the literature, it is only possible to say that *Dipteryx odorata* does not naturally occur in Nigeria, as it is a species from the Neotropics. The direct references to *Dipteryx odorata* are sporadic and inconclusive.

4.6. Using herbarium samples to map distribution of *Dipteryx odorata*

To try and determine the distribution of a species, other sources of primary information must be consulted and analysed. One such source of information is herbarium samples. For this study, I was able to access information of samples from the online databases of collections at Missouri Botanical Gardens, The New York Botanical Gardens and the Daubeny Herbarium, Oxford (Appendix 6.1.). From using records of herbarium samples, *Dipteryx odorata* is to be found in the following countries: Bolivia, Peru, Colombia, Brazil, Venezuela, Ecuador, French Guiana and Guyana (Figure 4.6.1.).

Fig. 4.6.1. The map shows the location of the available herbarium samples (marked with red stars), at the appropriate co-ordinate points.



4.7. Using names to determine distribution

Another method of obtaining evidence for the distribution of a species is to investigate the literature for patterns in given names. Where a plant provides a useful product it is commonly given a name, as obviously people need to identify and transfer information to others. A plant can be given many names if it has a wide distribution, because people name it according to their own, culture, language and

plant use. Overlap in names is also possible as information is shared between people and trading relationships are formed with neighbouring regions or countries.

If a timber is traded in a place were there is no previous knowledge or presence of the species it is usual that a common name will be adopted. Traded timber can sometimes gain a new name, depending on whom the timber is being marketed to. For example, Cumaru can be found under the name such as 'Brazilian Teak', 'Southern Chestnut' or 'Brazilian Chestnut' in advertisement of companies operating in the USA or the UK. These names reflect that companies are marketing to a people, who have some historical knowledge or acceptance of tropical timber such as 'Mahogany' or 'Teak'. Generally people accept a tropical wood if they are heavy and have a dark or rich colour. As very few people have the knowledge to know a true Mahogany or Teak wood. Which in its self is a trade myth considering that the true Mahogany, *Swietenia* of the neotropics, has been in the past and is currently substituted in the market by the genus *Khaya* of West Africa.

4.8 How names were categorised to provide evidence of distribution.

In reviewing *Dipteryx odorata* literature, all common, local, trade and commercial names that have been applied to this species were recorded. The names have been classified into four main groups: the trade or commercial names (here after trade name), the common or local names (here after common name), the seed names and finally foreign names. The category foreign names applies to what *Dipteryx odorata* is called in countries out-with the neotropics. Presumably they have a history of trading with the timber or the name is cited as used in a language that has a historical connection with the neotropics (Appendix 4.5).

Names were categorised as trade names in this list, if they were sourced from a reference that lists timbers of commercial importance, the name was found on a website of a timber importing or exporting company, or if it was cited in the literature directly as a recognised commercial or trade name of *Dipteryx odorata* (Appendix 4.3).

As a result of the trade in the seeds of *Dipteryx odorata,* the tree has many names that relate specifically to its seeds (Appendix 4.4)

Common names were recorded in this category where the source did not indicate if the name was a trade, seed or foreign name (Appendix 4.2).

To infer the natural distribution of the species using names as evidence, only the common or trade names were included in the analysis. From 36 sources consulted, 263 references to common or trade names referring to *Dipteryx odorata* were found.

Dipteryx odorata has 88 different common and trade names; 59 names applied to the trade category and 59 names to the common names category and there were 30 names in common. 18 foreign names were recorded and 16 names were applied to the trade in *Dipteryx odorata* seeds.

The presence of these different names in the literature can help to give an indication of the distribution of this species; 96% of the common names had a country associated with them and 67% of the trade names had the country name associated

with them. The number of times a name was found for each country it was recorded, to investigate the frequency of names that appeared in each country (Table 4.8.1.).

Table 4.8.1 The number of how many times the common and trade names were recorded to be associated with each country.

Country	Trade Names	Common Names
Belize	2	0
Bolivia	1	5
Brazil	26	44
Colombia	2	6
Costa Rica	6	1
El Salvador	2	0
French Guiana	7	20
Guadeloupe	0	1
Guatemala	2	0
Guyana	8	25
Honduras	6	0
Martinique	0	1
Mexico	2	0
Nicaragua	2	0
Panama	6	1
Peru	4	4
Suriname	9	11
Venezuela	3	17
Totals	**88**	**136**

4.9. Variation in the common and trade names of *Dipteryx odorata* and the limitations of using names to infer the distribution of a species

There are limitations in using only names to determine a species distribution. Firstly, the most common problem with these type of datum are that the names may not always apply to one species exclusively. Many different species can be assigned the same common or trade name, however this problem has been reduced by sourcing names that specifically refer to *Dipteryx odorata.*

With reference to the list of names that have been compiled for this study, there is much variation found between common and trade names. The vast area within which

Dipteryx odorata occurs means that there will be many communities living within the range of this tree. Their distribution, cultures and languages are incredibly diverse, therefore, so will be the range of names assigned *Dipteryx odorata*. These factors of language and culture obviously determine what name is assigned to a plant, how it is pronounced and eventually how it is spelt.

The difference between common names or trade names can be as small as a one letter difference which arises through the recording. Different languages and local accents will, in instances, change how a name is pronounced and then eventually, when it is recorded and how it is spelt. Therefore it becomes as established a new and different name (pers.com William Hawthorn). In this study the name 'Cumaru' commonly is used in Brazil to describe *Dipteryx odorata,* whereas the names 'Kumaru' or 'Koemaroe' are cited for *Dipteryx odorata* in Venezuela, Guyana (Spanish-speaking) and French Guyana (French-speaking), being cited as used in Brazil only once. When all three names are pronounced the similarity in their sound becomes apparent, and potentially to the origination from a common source.

'Gaiac de guyane', 'Gayac' de cayenne and 'Gayac' is another example from this data set where pronunciation of these three names revel their similarities. All three prefixes sound alike 'Gaiac' and 'Gayac' and the words 'guyane' and 'cayenne' sound similar when pronounced. They come from Venezuela, Guyana (Spanish-speaking) French Guiana and Guadeloupe (French-speaking), but again these are all recorded as different names as applied to *Dipteryx odorata.*

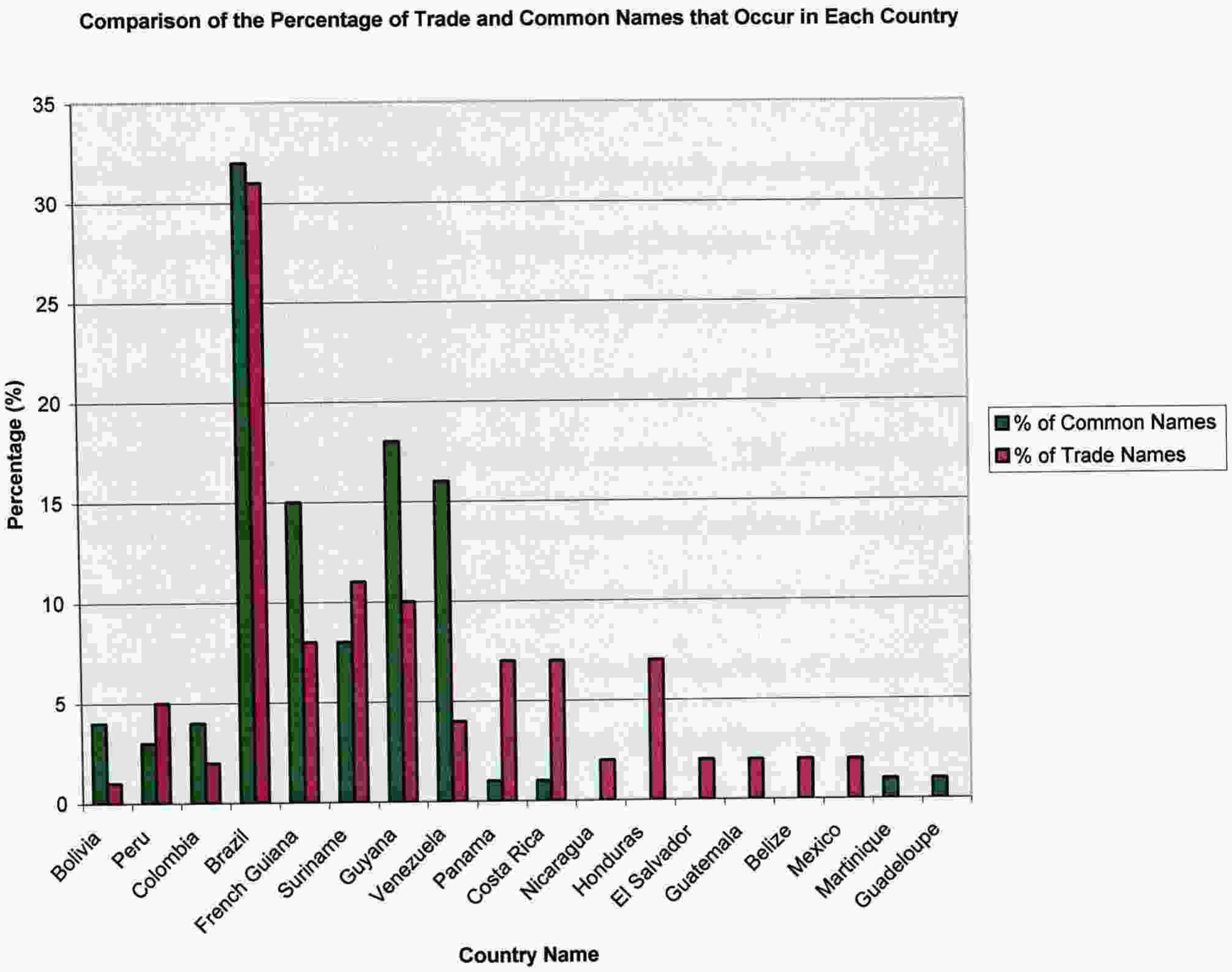
Variation in spelling of closely related names in relation to pronunciation could also indicate the vast diversity that will exist in languages, local accents and pronunciation. Variation in spelling could therefore be an indication of cultural and linguistic diversity and therefore, this correlation indicates the wider distribution of a species.

Obviously, a review of literature relies on where people have travelled and congregated to carry out research, and ultimately what becomes published. In the review of the literature of *Dipteryx odorata,* documentation of species presence in Ecuador was not found, however a herbarium sample has been collected from Ecuador, and is held at the Missouri Botanical Gardens.

Common names are usually retained for use when they become a trade name for a species. It is much easier to use an already existing name for a plant. This makes the aspect of trading, relating or asking information about the plant or product obtained from it much simpler. From the review of the literature for *Dipteryx odorata,* 53% of the common names are also trade names.

4.9.1 Distribution of *Diptreyx odorata* using Common Names and Trade Names

Fig. 4.9.1. The percentage of common names that are associated with each country and the percentage of trade names associated with each country. The countries on the graph have been arranged so that their order from left to right follows as closely as is possible the countries arrangement from the most southern latitudes through to those that have the most northern latitudes.



4.9.2. The natural distribution or distribution of where *Dipteryx odorata* has a long history of use or recognition

If common names are assumed to originate in the countries where the species occurs naturally, the development of common names can be correlated with cultural use, as opposed to trade names, where they are passed between cultures at greater geographical distances and diversity.

Figure 4.9.2. shows that *Dipteryx odorata* is widely distributed over the Amazonian basin. In the peripheral countries of the Amazonian basin were less species or trade names exist, Peru, Bolivia and Colombia, it is probably due to the fact that only a small part of the country lies within the Amazon basin, and for *Dipteryx odorata* this is the limit of its ecological range.

In the countries of Panama and Costa Rica 14% of the trade names and only 1.5% of the common names correlate with Peru, Bolivia and Columbia. On the basis of the evidence Panama and Costa Rica are likely to be the northern limit of the natural population or were an introduced or colonising population of *Dipteryx odorata* has a longer history than in other Central American countries. The coastal regions of French Guiana, Suriname and Guyana were very important regions for the production of Tonka beans last century (Pesce 1985). Either they developed as important areas because coastal regions allow access to ports for easier exporting of the seeds or that the species naturally is very productive in this range. The northern tip of Guyana is on the same latitude as the southern tip of Costa Rica, approximately 8^0 north of the equator. It is possible that seeds could have travelled or been carried progressively along the coast eventually reaching Panama, Costa Rica, Venezuela and the Guianas and perhaps the tree has become established there and could possibly indicate the origin of a common name for it within the country.

4.10. Distribution of *Dipteryx odorata* as a recently introduced species

As there are no common names associated with any other Central American countries, it is inferred that the presence of the species is due to introduction for cultivation. As Costa Rica, Panama and Honduras have more trade names (each country has 14% of the total trade names found) than the peripheral countries of the Amazon Basin, Bolivia, Columbia, Peru and Ecuador, they have 1.1%, 2.3%, 4.5% and 0% respectively of the total number of trade names. In Costa Rica, Panama and Honduras, it implies there is or was an importance of this species in cultivation and trading of either timber or seeds. The important presence in these three countries is likely to have lead to the spread of *Dipteryx odorata* throughout the rest of Central America, most likely due to anthropogenic movements for cultivation. There is evidence that the species also has a distribution in the Caribbean.

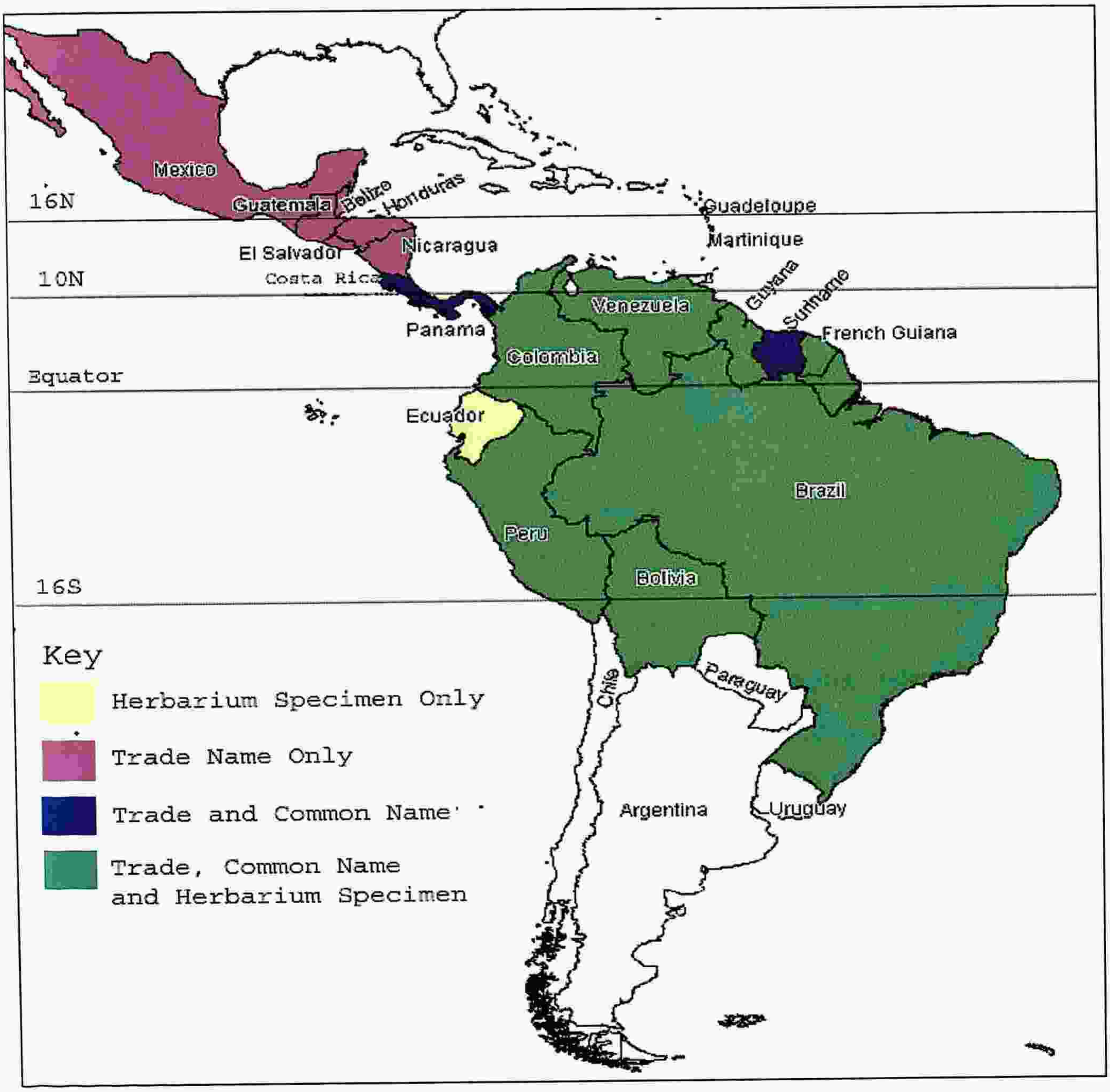
The existence of common names in Guadeloupe and Martinique (of the windward islands) could indicate the presence of the species naturally. Species of Mahogany *Sweitina* and *Cedrela odorata* are naturally found in the southern and windward isles of the Caribbean, that are common on the south American continent. Or the presence of the species may also be related to anthropogenic factors, as there are close historical links that exist between these islands and French Guiana. The common names either became established if the tree occurs naturally, or if *Dipteryx odorata* was cultivated, or products of the tree, (either timber or seeds) was moved between these countries. The historical link of the common names in these islands with French Guiana is reinforced by the fact that only one name appears for Guadeloupe, 'Gayac de cayenne' (Cayenne being the capital of French Guiana). This common name is only found another two times in the common names lists associated solely with the

country French Guiana. Similarly, the common name found in Martinique, 'Bois de Coumarouna', it has only one common name similar to it, 'Bois de Coumarue', again from French Guiana. It is possible that processing happened in the Caribbean islands, as alcohol is needed to process the seeds to obtain the coumarin. For example, it is reported that seeds from Venezuela were exported to Trinidad for the processing and were soaked in rum for the process of crystallization to obtain the cumarin extract (Uphof 1968, Pesce 1985).

4.11. Placing the species *Dipteryx odorata* on the Map

On the basis of the evidence presented Figure 4.11.1. *Dipteryx odorata* reaches its southerly limit at approximately 16^0 south of the equator, due to the presence of a common name recorded in Beni, Bolivia (Killeen *et al.* 1993) at the edges of the Bolivian Amazon basin. The southern tip of the state of Mato Grosso, Brazil lies at approximately 16.5^0 south of the equator; with reference to the names Kumbaru and Cumaruzerio from this state (Corrêa 1984). The most southerly herbarium sample is at 16.35^0 south at Santa Cruz, Bolivia. The natural or long history of existence in the country of *Dipteryx odorata* reaches its northern limit at approximately 11^0 north considering the countries of Panama and mid way through Costa Rica as the northern limit. If Martinique and Guadeloupe are considered as natural range of the species, the northern limits extends to approximately 16.5^0 north of the equator. The current cultivated limit of *Dipteryx odorata* in Latin America is approximately 33^0 north of the equator.

Fig. 4.11.1. The map shows the distribution of *Dipteryx odorata* using the three sources available, common names, trade names and herbarium specimens. The southern limit is indicated at approximately 16^0 south, the natural or history of long establishment at approximately 11^0 north, and the extended northern limit considering the distribution in Guadeloupe and Martinique at 16.5^0 north. The northern cultivated limit is at 33^0 north of the Equator at the top of Mexico.



Chapter 5 – Ecology and Distribution of *Dipteryx odorata*

5.1. Phenology

5.1.1. The flowers and flowering period.

Dipteryx odorata flowers late in the dry season, September to October, around Manaus, and around Belém, October to November. Variations can occur depending on the level of rainfall. Fruits take nine months to mature, and are disseminated towards the end of the wet season, May to July around Manuas and June to August around Belém (Alencar *et al*. 1979). The flowers of *Dipteryx odorata* are cited to be whitish to pinkish rose in colour (Macbride 1943, Killeen *et al.* 1993) and rosy-purple to crimson (Loureiro *et al*., 1968, Axtell *et al*. 1992). Loureiro *et al*., (1968) suggest that the flowers are initially pinkish white in colour and develop later in the dry season to a rosy-purple to a crimson colour and have a strong scent. This suggests that there is post pollination colour change taking place, as is common in other species. The flowers have been cited in one source, Rico (1988) to be the colour blue, but this is most likely a mistake, as blue flowers are very distinct in colour from other pigments.

5.1.2. Flower visitors

The information on pollinators of *Dipteryx odorata* is not available from the literature (pers.com Giorgio Venturieri 2002). However, during the flowering period there are visitors to the flowers, chiefly bees, including medium sized (10 – 25 cm), that are social bees principally of the families *Meliponinae* and *Apinae* and solitary bees (10 - 25 cm) (pers.com Giorgio Ventura 2002), and some moths. The pollination period lasts 3 - 4 weeks (Embrapa Seed Lab, Belém, Brazil).

5.1.3. Fruits and fruit production

The fruits are a popular food source for bats, despite the mesocarp's disagreeable odour and resinous composition (Pesce 1985) however, this is a classic characteristic of fruits dispersed by bats (per.com Stephen Harris). Bats are cited as dispersal agents for *Dipteryx odorata* in Costa Rica (Janzen 1983; Embrapa Seed Lab, Bélem, Brazil). Each fruit contains a single hard, smooth, dark purple-red seed that is approximately 2.5 - 3 cm long (Ducke 1948). The weight of an average seed is 7.3 grams (FAO, 2002). Four years after establishment in a plantation *Dipteryx odorata* was found to produce fruits (Azevedo *et al.* 1999). The tree produces approximately 3.7 kg of seeds (Silva *et al.* 1977; FAO, 2002).

As with the incidence of flowering, the seed productivity of the tree is also affected by the rainfall levels throughout the year. When there is plenty of rain, the tree will have a good mast year potentially producing on average between 300-350 kg of seeds per year. In a year with little rain, the productive capacity of each tree diminishes to 30 kg of seeds per year (Gonçalves 2001). (The seeds for the study conducted by Gonçalves 2001 were collected between May and July the end of the wet season in the Flona Tapajós, Pará, Brazil).

5. 2. Habitat

Dipteryx odorata is found in primary rainforest (Macbride 1943, Marenco *et al.* 2001), and reaches its best development on well-drained gravely or sandy soils (Chudnoff 1984, Pesce 1985). It is said to occur in the upland forests of Pará, Brazil (Pesce 1985) and it is also said to be found in the drier parts of the upland forests off

the Brazilian Amazon and French Guiana (Axtell *et al.* 1992). *Dipteryx odorata* is also found in savannah forests (Berni 1979). It is a late successional species and is adapted to colonizing small gaps (Marenco *et al.* 2001). *D.odorata* is found between altitudes of 0 and 850 m above sea level (Brako *et al.* 1993, Missouri Botanical Gardens 2002).

5.3. Population structure *Dipteryx odorata*

The density of trees in a humid tropical forest can range over the forest landscape depending on how the local climate and soil types affect the growth, development and distribution of the tree. The distribution of pollinators and dispersers also affect the ultimate distribution of a tree species. Tropical tree species can be found to dominate a certain area if conditions are favourable for them to exploit the existing ecological niche (Wadsworth 1997). The main of distribution of trees in tropical forests is to find them clumped, randomly or hyper-dispersed (Terbourgh 1992).

Table 5.3.1. This table gives figures on the density of trees per hectare, in different regions of Brazil and the associated volume were it was available.

Study site	**Number of trees/ hectare**	**Volume (m^3)/ Hectare**	**Minimum dbh (cm) used in study**	**Author**
Forests of Amapá, Brazil	2.3			FAO mission 1956-61, SUDAM 1975
Curua-Una River, Brazil	0.8			FAO mission 1956-61, SUDAM 1975
Cametá, Pará, Brazil		4.3		FAO mission 1956-61, SUDAM 1975
Lower Tocantins River, Pará, Brazil		3.5		FAO mission 1956-61, SUDAM 1975
Flona Tapajós, Santarém, Pará, Brazil	0.2			(Gonçalves 2001)
Manaus – Itacoatiara highway (AM-010), Brazil	0.03	0.85	> 45cm	((Lourerio et al. 1979) FAO 2002)
Manaus – Itacoatiara highway (AM-010), Brazil	0.3	0.65	>25cm	((Lourerio et al. 1979) FAO 2002)
Suframa's Agricultural District, Brazil	0.125	0.83	>20cm	((Jardim 1985) FAO 2002)
Presidente Figueiredo, Amazonas, Brazil (300km north Manuas), Brazil	0.02	0.21	60-70cm	((Poyry 1984) FAO 2002)
Novo Aripuaná, S. Amazonas, Brazil	0.57	2.4	>45cm	((Jardim & Fernandes 1983) FAO 2002)

The density of trees ranges from 0.02 to 2.3 trees per hectare. The number of trees per hectare is not really comparable for the figures given in Table 5.3.1. The density was calculated using four different dbh size classes out of the five results that are present. In the regions of Curua-Una river, Flona Tapajós, Manaus-Itacoatiara highway and in

the State of Amazonas the data indicates that *Dipteryx odorata* occurs at a low density (0.02 to 0.8 trees per hectare) in contrast with the forests measured in Amapá state where 2.3 trees per hectare are found. The minimum dbh is not given for this result in Amapá, making it impossible to judge if the high number of trees quoted per hectare is due to the fact that perhaps a small dbh was used to derive the figures. This data is limiting in that it is not comparable as sample plot size is not indicated and different dbh classes were used. As the sample plot size is not indicated it is impossible to make any judgement about the distribution of the population. There is no valuable data to indicate the population structure, nothing was measured under 25 cm dbh therefore no information on the seedling or sapling dynamics of the stand could be inferred.

A forest concession that is for sale in the Silves, Amazonas state in Brazil advertised by BMA Commodity (BMA Commodity Investment 2002), provides an interesting contrast to the above figures for the number of trees per hectare. The concession is advertised as 3,000,000 hectares in total. The trees present are named by 29 common names. For Cumarú, which could potentially be the species *Dipteryx odorata* (as the name Cumarú has very wide spread use for *Dipteryx odorata*), the company cites that there are 20 trees per hectare of Cumaru (BMA Commodity Investment 2002), (the minimum diameter is not indicated). The concession is being sold as a commercial logging development. This may indicate why the number of trees per hectare is so high, or that no real inventory has been done in the concession. The other 28 trees, named by their common names, appear at density of either 10 or 20 trees per hectare.

5.4. Potential use of *Dipteryx odorata* in reforestation and agroforestry

Dipteryx odorata's potential as a species for afforestation of degraded lands was investigated by Azevedo *et al.* (1999) and Marenco *et al.* (2001). Both studies tested it in open field plots and in mixed agroforestry where *Dipteryx odorata* was given shade. Marenco *et al.* (2001) reported that the species did better under a small amount of shade than in an open field environment. *D.odorata* is recommended as a good species for use in afforestation purposes (Loureiro *et al.*1968, Azevedo *et al.* 1999, Marenco *et al.* 2001). As *Dipteryx odorata* is suitable for planting in full sun and partial shade, it is suggested as a potential tree for afforestation and agroforestry systems as it is fast growing. (Loureiro *et al.*1968, Azevedo *et al.* 1999, Marenco *et al.* 2001), it could provide a multipurpose component to an agroforestry system if a market is found for the seeds that it produces.

Chapter 6 - Species with the same common or trade names as the species *Dipteryx odorata,* or the genus of *Dipteryx.*

Common names are not exclusively applied to one organism. Species that are similar in morphology or function are likely to have some vernacular names in common. In a study undertaken in the timber yards of different timber exporting companies in Belém, Brazil, it was found that four species of the genus *Manilkara* (family *Sapotaceae*) were managed under the common name 'Massaranduba' and similarly in the same timber yards it was found that threespecies of *Couratari* (family *Lecythidaceae)* and one species of *Cariniana* species, (family *Lecythidaceae*) were all managed under the common name 'Tauari' (Kanashiro *et al.* 2002). Information provided by DLH Nordisk, Belém, Brazil reported that the main species bought as 'Cumaru' is *Dipteryx odorata* but that other species were mixed in with it (Andre Franco pers.com., DLH Nordisk 2002).

From a review of the literature, 13 species were found to have a vernacular name in common with *Dipteryx odorata.* From these 13 species, 61 different common names are cited. Only one species, *Apuleia molaris* was from the *Fabaceae* family, subfamily *Caesalpinioideae*, all the rest were from family *Fabaceae,* subfamily *Papilionodeae* (Appendix 6.1.). There are two species which have the same trade name as *Dipteryx odorata,* they are *Dipteryx oleifera* and *Dipteryx trifoliate,* (Appendix 6.1.1.), the trade name in common being 'Almendro' (Kribs 1968).

Table 6.1 gives the number of times a species was referenced in the literature to have the same common name as *Diptreyx odorata*, the second column gives the number of individual common names that were found for each species. *Dipteryx oleifera* (49

names), *Dipteryx trifoliata* (32 names) have the most vernacular names in common with those as applied to *Dipteryx odorata*. In areas of the Brazilian Amazon, *D.odorata* is called Cumarú or Cumarú-zerio; they are vernacular names applied to the species which posses odorous seeds. Cumarú-rana is the vernacular name given to other species in the genus with inodorous seeds, or that bear a resemblance to the real Cumarú in its bark, form, wood or fruit, with only the 'rana' denoting 'false' (Ducke 1940, Hess *et al.* 1950). *Dipteryx polyphylla* has seeds that are identical in shape and size to the seeds of *D.odorata,* except the kernels are odourless (Pesce 1985).

Table 6.1 All the species which have a vernacular name in common with *Dipteryx odorata*, it gives the number of times the species was cited in the literature, and the number of different vernacular names that it has in common with those common names of *Dipteryx odorata*.

Species	Number of Reference per Species	Number of common names
Amburana acreana	2	2
Amburana cearensis	1	1
Andira inermis	3	3
Apuleia molaris	2	1
Dipteryx ferrea	2	1
Dipteryx magnifica	1	1
Dipteryx oleifera	75	49
Dipteryx panamensis	6	2
Dipteryx polyphylla	1	1
Dipteryx punctata	2	2
Dipteryx trifoliata	40	32
Geoffroya inermis	1	1
Taralea oppositifolia	2	1

The genus *Poecilanthe* is a member of another sub-family of *Fabaceae,* it belongs to the sub-family *Caesalpineae* Table 6.2. The common names Cumarú de cherio and Cumarú-rana are given to *Dipteryx odorata,* they are cited by Macbride (1943), to apply to the genera *Amburana* and *Taralea* with Cumaru applying to the genus *Poecilanthe.* The entries for *Torresea* were described in the literature as two different species of *Torresea* that can have the name Cumarú de cheiro, although which two species of *Torresea* were not detailed (Ducke 1940).

Table 6.2 Genera that have a vernacular name the same as *Dipteryx odorata.* The entries for *Torresea* are with reference to 2 different species but only the genus was given in the literature.

	Genus	Common Name	Country Where Name Used	Author
Papilionoideae	*Amburana*	Cumarú de cheiro		Macbride (1943)
Papilionoideae	*Amburana.*	Cumaru		Howard (1948)
Caesalpineae	*Poecilanthe.*	Cumaru		Howard (1948)
Papilionoideae	*Taralea*	Cumarú-rana		Macbride (1943)
Papilionoideae	*Torresea sp1.*	Cumarú de cheiro	Brazil	Ducke (1940)
Papilionoideae	*Torresea sp2.*	Cumarú de cheiro	Brazil	Ducke (1940)

Table 6.3 details the 11 common names that are cited in the literature to apply to the naming of all the different species of the genus *Dipteryx.* At present count 54 names exist for this genus (INPI 2002).

Table 6.3 The common names that are cited in the literature to apply to the whole genus of *Dipteryx*.

Family	Genus	Common Name	Country Where Name Used	Author
Papilionoideae	*Dipteryx*	Krameria	Peru	Macbride (1944)
Papilionoideae	*Dipteryx*	Sarrapia	Venezuela	Aristeguieta (1973)
Papilionoideae	*Dipteryx*	Sarrapia	Venezuela	Ducke (1940)
Papilionoideae	*Dipteryx*	Sarrapia mono	Venezuela	Aristeguieta (1973)
Papilionoideae	*Dipteryx*	Sarrapia real	Venezuela	Aristeguieta (1973)
Papilionoideae	*Dipteryx*	Yape	Venezuela	Aristeguieta (1973)
Papilionoideae	*Dipteryx*	Cumarú	Brazil	Ducke (1940)
Papilionoideae	*Dipteryx*	Cumaru ferro	Brazil	Ducke (1940)
Papilionoideae	*Dipteryx*	Cumarú	Brazil	Ducke (1943)
Papilionoideae	*Dipteryx*	Cumarú-rana	Brazil	Ducke (1940)
Papilionoideae	*Dipteryx*	Cumaruzeiro	Brazil	Ducke (1940)
Papilionoideae	*Dipteryx*	Cumaru roxo		da Silva *et al*. (977)
Papilionoideae	*Dipteryx*	Cumaru verdadeiro		da Silva *et al*. (1977)

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Further research could determine what differences there are that exist between the species in Table 6.1 and *Dipteryx odorata,* to the differences in morphology, growth habits or in the structure of the wood. The genus of *Dipteryx* also needs further investigation to determine what differences exist between the species of this genus and *Dipteryx odorata.* Of particular advantage would be what characteristics could be found in the field that differentiate the species. Determining the differences between the wood characteristics of the genus would have a practical application in identifying the species at timber yards to determine the frequency of mixing of different species of the same genus and different genera's. This could help identify which species need more in depth investigation of their characteristics at the source, in the forest .

Chapter 7 - Wood Identification

7.1 Wood Characteristics and Identification

A hand lens can be used to identify wood characteristics such as the pores (size and number), parenchyma, included phloem, intercellular canals, oil cells, mucilage cells, vertical elements and the rays (width and number) the features have a diagnostic function (Henderson 1952).

Some species used in the timber trade are confused with or they have the same common or trade name as *Dipteryx odorata* (Appendix 6.1 and Appendix 6.1.1.). There are two genera that have the name Cumaru applied to them, *Amburana* and *Poecilanthe* (Howard 1948; Chapter 6, Table 6.2). Thirteen species have the same common or trade names in common as applied to *Dipteryx odorata: Amburana acreana, Amburana cearensis, Andira inermis, Apuleia molaris, Dipteryx ferra, Dipteryx magnifica, Dipteryx oleifera, Dipteryx panamensis, Dipteryx polyphylla, Dipteryx punctata, Dipteryx trifoliate, Geoffroya inermis* and *Taralea oppositifolia.* (Ducke 1940, 1943, Macbride 1943, Howard 1948, Hess *et al.* 1950, Wangaard *et al.* 1952, Kribs 1968, da Silva *et al* 1977, Pesce 1985 and Chichignoud *et al.* 2001). For this reason it is useful to look at these species that are confused in common or trade name with *Dipteryx odorata* and to compare the wood characteristics to see if there are any obvious differences that are between them.

The wood samples used were from the Oxford Forestry Institute Wood Collection (FHOw). There were only two wood samples that matched the species exactly; *Dipteryx odorata* and *Andira inermis.* Were the exact species was not present it was sufficient to use another species from the same genus, to attempt to gauge some general features of the genera. Three other species were examined from the genus *Dipteryx* to determine common characteristics. No samples were available for the genera of *Taralea* and *Poecilanthe.*

Table 7.1 The wood samples that were examined, with (FHOw) number, collector, the country where the collection was made.

Sample Number (FHOw)	Sample Species Scientific name	Collector	Origin of Sample (Country)	Pore Number (per 10 mm^2)	Pore Size Class, Size mm	Ray Size Class, Size mm	Ray Number (per 5mm)
1 1280	*Amburana cearensis*	F.E. Devote	Argentina	12 – 30	4 to 5, 0.1 – 0.3	3 or less, <0.05	25 - 50
882	Andira inermis		Guyana	12 - 30	5, 0.2 – 0.3	4, 0.05 – 0.1	25 - 50
3483	*Andria inermis*	Cooper & Slater	Panama	12 - 30	5 to 6, 0.2 – 0.4	3 or less, < 0.05	25 - 50
9706	*Apuleia praecox*		Argentina	65 - 125	4, 0.1 – 0.2	4, 0.05 – 0.1	25 - 50
11281	*Apuleia praecox*	F.E. Devote	Argentina	65 - 125	3, 0.05 – 0.1	Not visible with hand lens	Not visible with hand lens
2926	Dipteryx odorata		Brazil	30 – 65	4, 0.1 – 0.2	3 or less, <0.05	25 - 50
18885	Dipteryx odorata	Dr.J.F. Kools	Surinam	30 – 65	4, 0.1 – 0.2	4, 0.05 – 0.1	25 –50
20372	*Dipteryx oppositifolia*	B.A. Krukoff	Brazil	30 – 65	5, 0.2 – 0.3	4, 0.05 – 0.1	50 - 80
20388	*Dipteryx oppositifolia*	B.A. Krukoff	Brazil	30 - 65	4 to 5, 0.1 – 0.3	3 or less, <0.05	50 - 80
20386	*Dipteryx aff. polyphylla*	B.A. Krukoff	Brazil	30 - 65	5, 0.2 – 0.3	3 or less, <0.05	50 - 80
10122	*Dipteryx punctata*		Guyana	30 - 65	3, 0.05 – 0.1	3 or less, <0.05	50 - 80

7.2 Wood Description

Dipteryx odorata is marked by prominent vessel lines and the closely interlocked grain produces a consistent narrow stripe on the radial surface (Hess *et al.* 1950, Berni 1979).

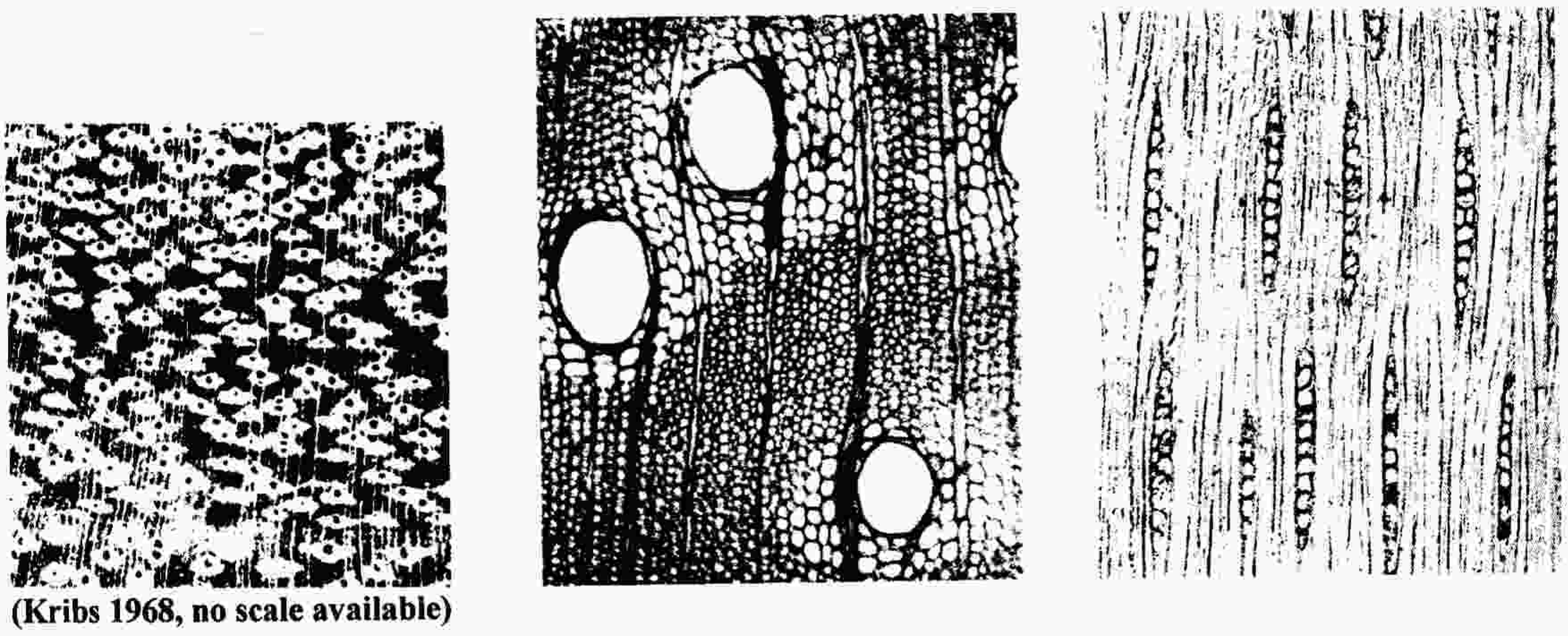
7.2.1. *Dipteryx odorata*

Pores (vessels); are tangentially arranged, appear as clusters the pore groups are arranged radially. The perforation plates are simple in structure and there is no spiral thickening present. Intervascular pitting is minute and alternate, there are no tyloses or gum deposits present, pores number 30 to 65 pores per $10mm^2$, **size,** the pores are fairly distinct to the naked eye and are in size class 4, (0.1 to 0.2 mm) in diameter, mean tangential diameter less than 100µ. **Intercellular Canals;** there are none of these structures present, **Fibres and Fibre-Tracheids;** there are no septate structures present in the fibres, the fibres are thick to medium walled. There are no fibre tracheids present, **Tracheids;** there are none of these structures present, **Parenchyma:** distinct to the naked eye, the distribution is predominately associated with the pores (paratracheal), they are aliform (wing-like lateral extensions surrounding the pores) and confluent. **Miscellaneous Features;** there was no included phloem or intercellular canals observed, the vertical elements are storied, axial elements storied, oil or mucilage cells present, **Rays; width,** the rays are heterogeneous and storied, the rays are size class 4, (0.05 to 0.10 mm) (FHOw 18885) or size class 3, (< 0.05 mm) (FHOw 2926) **number;** the number of rays range from 25 to 50 per 5mm (FHOw 18885), 50 to 80 per 5 mm (FHOW 2926), there are commonly 3 or more rays per pore; the rays are less than 1mm in height, the ray tissue is homogenous and no aggregate rays are present, the bi-seriate portions are no

wider than the uni-seriate portions, there are no tile cells present and the rays and fibres are not storied, pits to vessels are very small, pits are similar in size and are less than 10μ in diameter, they are similar in shape to the intervascular pitting, **Crystals;** these were not present due to the antiquity of the slide material.

Material studied: FHOw 2926, FHOw 3340, FHOw 18885.

Fig.7.2.1. Wood surface cross section and the microscopic cross and radial sections of *Dipteryx odorata*.



(Kribs 1968, no scale available)

7.2.2. *Dipteryx oppositifolia*

Pores (vessels); the pores are tangentially arranged and appear as clusters. It was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, pores number 30 to 65 per $10mm^2$, **size,** the pores range between size classes 4 and 5, (0.1 to 0.2 mm) and (0.2 to 0.3 mm) respectively, to the naked eye they are fairly distinct to being easily viable at a normal reading distance for (FHOw 20388) and (FHOW 20372) are in size class 5, (0.2 to 0.3 mm), they are easily visible at a normal reading distance, **Parenchyma;** are distinct to the naked eye, the distribution is predominately associated with the pores (paratracheal), they are aliform (wing-like) in structure, **Miscellaneous Features;** there was no included phloem or intercellular

canals observed, the vertical elements are storied. **Rays; width,** the rays are in size class 3 (< 0.05mm) (FHOw 20388) and (FHOw 20372) they are in size classes 4 (0.05 to 0.1 mm) the rays are heterogeneous and storied. **Number;** the number of rays range from 50 to 80 per 5 mm. There are commonly 3 or more per pore, no aggregate rays were observed.

Material studied: FHOw 20372, FHOw 20388.

7.2.3. *Dipteryx polyphylla*

Pores (vessels); are tangentially arranged and appear as clusters. It was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, pores number 30 to 65 per 10mm^2, **size,** the pores are in size class 5, (0.2 to 0.3 mm) they are easily visible at a normal reading distance, **Parenchyma;** are distinct to the naked eye, the distribution is predominately associated with the pores (paratracheal), the parenchyma are confluent in structure, **Miscellaneous Features;** the was no included phloem or intercellular canals observed, the vertical elements are storied. **Rays; width,** the rays are in size class 3, (< 0.05 mm) the rays are storied, **number,** the number of rays range from 50 to 80 per 5 mm, there are commonly 3 or more per pore, no aggregate rays were observed.

Material Studied: FHOw 20386.

7.2.4. *Dipteryx punctata*

Pores (vessels); the pores are tangentially arranged and appear as clusters, it was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, pores number 30 to 65 per 10mm^2, **size,** the pores are in size class 3 (0.05 to 0.1 mm) they are just visible to the naked eye, **Parenchyma;** the parenchyma are distinct to

the naked eye, the distribution is predominately associated with the pores (paratracheal), the parenchyma are confluent in structure, **Miscellaneous Features;** there was no included phloem or intercellular canals observed. The vertical elements are storied, **Rays; Width;** the rays are in size class 3 (<0.05 mm), the rays are heterogeneous and are not storied, **number;** the number of rays range from 50 to 80 per 5 mm, there are commonly 3 or more per pore, no aggregate rays were observed.

Material Studied: FHOw 10122.

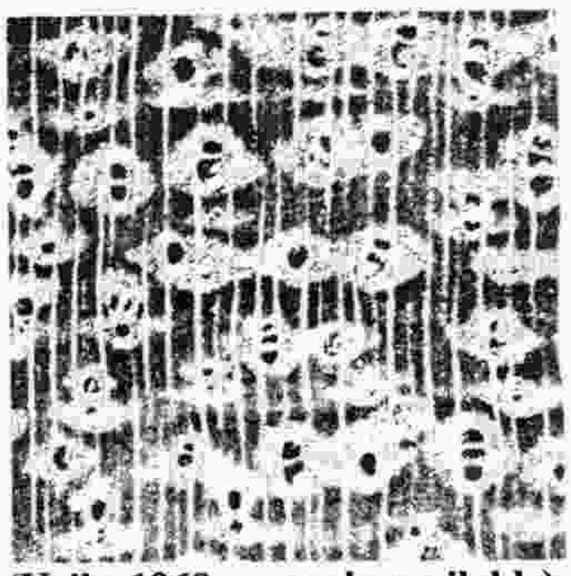
7.2.5. *Amburana cearensis*

Pores (vessels); the pores are tangentially arranged and appear as clusters. it was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, **number,** pores number 12 to 30 per $10mm^2$, **size,** the pore sizes range between size class 4 and 5, (0.1 to 0.2 mm) and (0.2 to 0.3 mm) respectively, to the naked eye they are fairly distinct to being easily visible at a normal reading distance, **Parenchyma;** distinct to the naked eye, the distribution is predominately associated with the pores (paratracheal), they are aliform (wing-like) and confluent in structure, **Miscellaneous Features;** there was no included phloem or intercellular canals observed. The vertical elements are not storied. **Rays; width,** the rays are in size class 3 (<0.05 mm). The rays are heterogeneous and are not storied, **number,** the number of rays range from 25 to 50 per 5 mm, there are commonly 3 or more per pore, no aggregate rays were observed.

Material studied: FHOw 11280

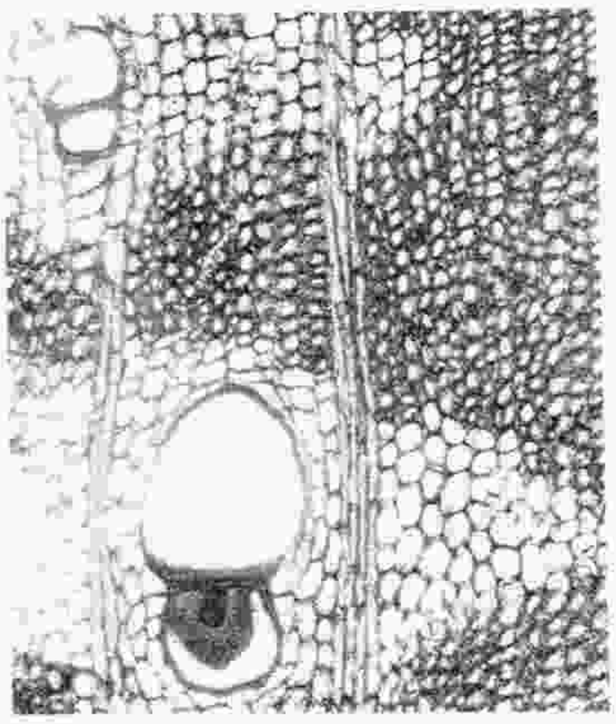
Fig. 7.2.2. Wood surface cross section and the microscopic cross and radial sections of *Amburana cearensis*.

Cross Section (Hand lens)

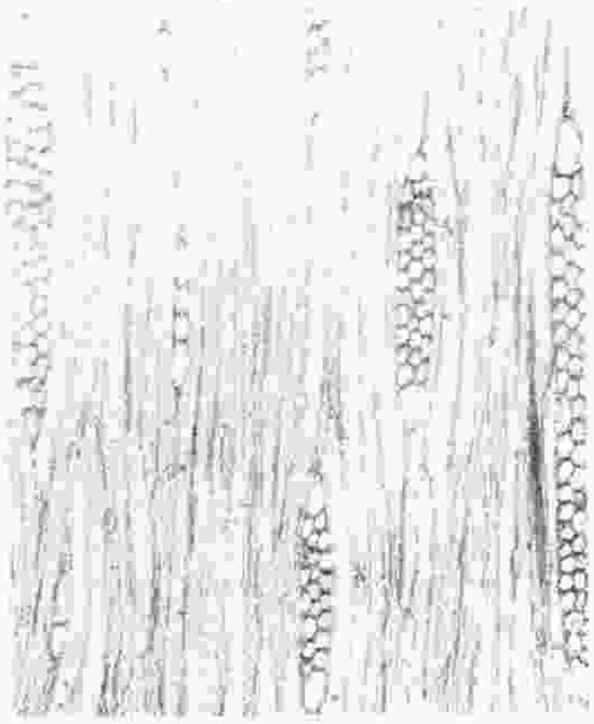


(Kribs 1968, no scale available)

Cross Section (Microscopic)



Radial Section (Microscopic)



7.2.6. *Andira inermis*

Pores (vessels); the pores were observe in a radial or oblique arrangement, no pore clusters were observed, it was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, pores number 12 to 30 per $10mm^2$, **size,** the pores range between size classes 5 and 6, (0.2 to 0.3 mm) and (0.3 to 0.4 mm) respectively, they are easily visible at normal reading distance and still visible at arms length, **Parenchyma;** are absent or indistinct with the hand lens. The distribution is predominately associated with the pores (paratracheal), the parenchyma are banded confluent and conspicuous in their arrangement, **Miscellaneous Features;** there was no included phloem or intercellular canals observed, the vertical elements are not storied, **Rays; width,** the rays are in size class 3 (< 0.05 mm) (FHOw 3483), and (FHOw 882) the rays are in size class 4 (0.05 to 0.1 mm), the rays are heterogeneous and are not storied, **number,** the number of rays range from 25 to 50 per 5 mm, there are commonly 3 or more per pore, no aggregate rays were observed.

Material studied: FHOw 882, FHOw 3483

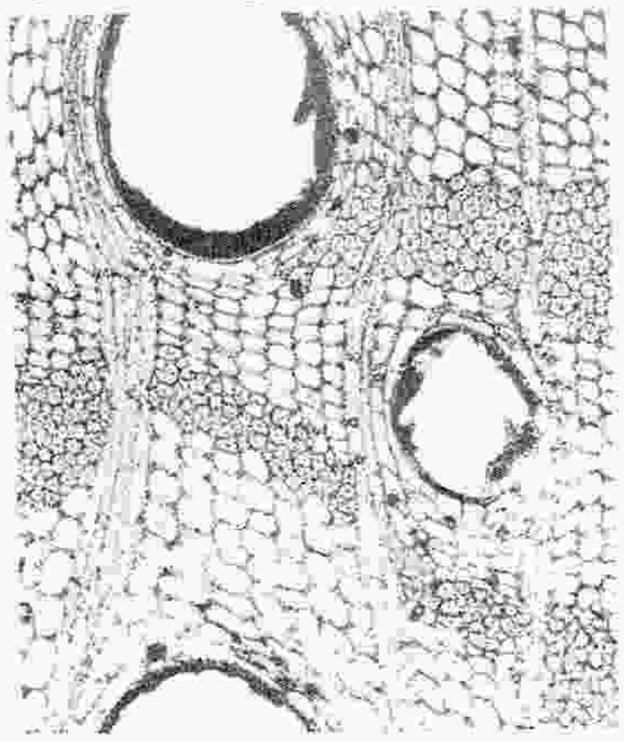
Fig.7.2.3. Wood surface cross section and the microscopic cross and radial sections of *Andira inermis.*

Cross Section (Hand lens)

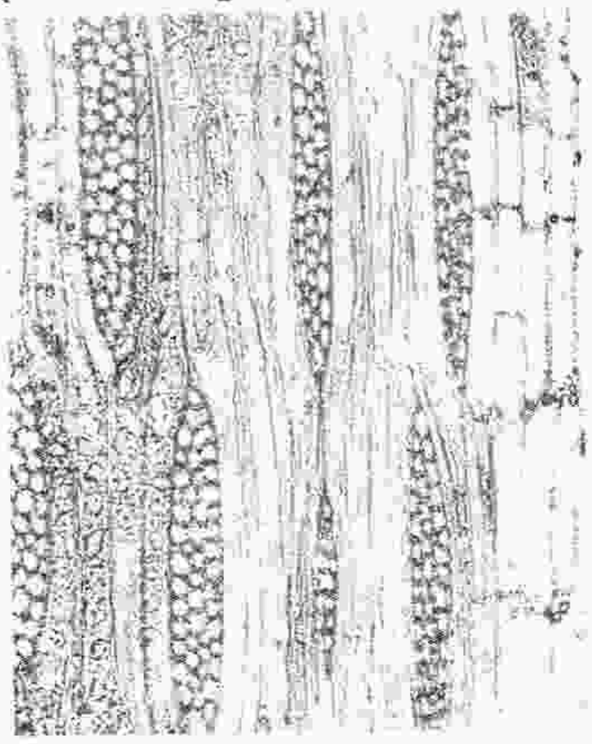


(Kribs 1968, no scale available)

Cross Section (Microscopic)



Tangential Section (Microscopic)

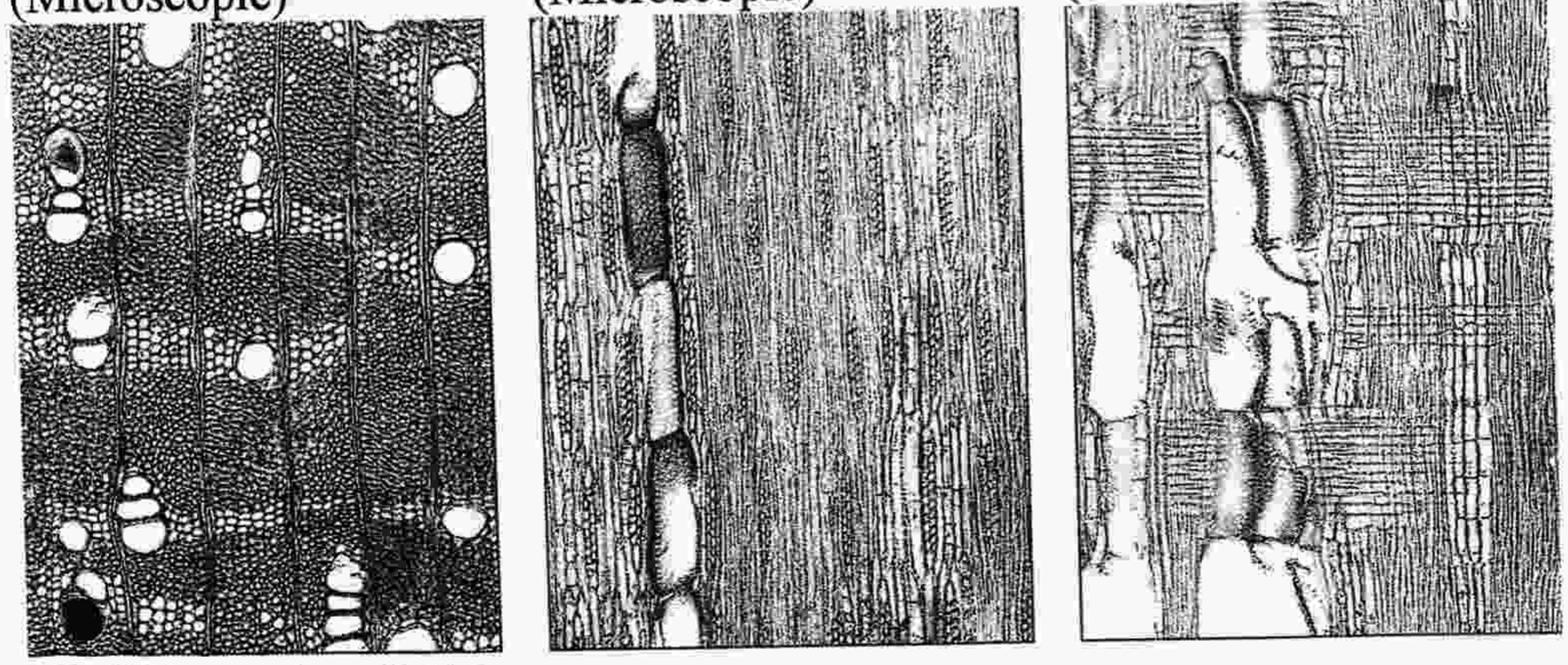


7.2.7. *Apuleia praecox*

Pores (Vessels); were observe in a radial or oblique arrangement, pore clusters were observed, it was not possible to observe perforation plates, tyloses or gum deposits with the hand lens, pores number 65 to 125 per $10mm^2$ **, size,** the pores are in size class 4, (0.1 to 0.2 mm), the pores are fairly distinct to the naked eye, (FHOw 9706) and (FHOw 11281) the pores are in size class 3, (0.05 to 0.01 mm), they are just visible to the naked eye, **Parenchyma;** are absent or indistinct with the hand lens, the distribution is predominately associated with the pores (paratracheal), the parenchyma are confluent in structure and banded in arrangement, **Miscellaneous Features;** the was no included phloem or intercellular canals observed the vertical elements are not storied, **Rays; width,** the rays are in size class 4, (0.05 to 0.1 mm) the rays are heterogeneous and are not storied, **number;** the number of rays range from 25 to 50 per 5mm, some aggregated rays were observed. FHOw 11281 the rays were not visible with a hand lens.

Material studied: FHOw 9706, FHOw 11281

Fig. 7.2.4. Microscopic cross section, tangential section and radial section of *Apuleia praecox.*



(Ilic 1991, no scale available)

7.3. Wood Microscopic Identification and Description

It was possible to make a description using the microscopic cross section, tangential section and the radial section for *Dipteryx odorata* (Section 7.2.1 and Figure 7.2.1.) and *Dipteryx magnifica* using microscopic features for identification.

7.3.1. *Diptreyx Magnifica*

Pores and vessels; the pores appear in clusters and are arranged radially in pore groups. The perforation plates are simple in form and there is no spiral thickening present. The intervascular pitting is minute and the pits are arranged alternately. There are no tyloses or gum deposits present**, Pore Size;** mean tangential diameter less than 100μ, the larger pores in this group are just visible to the naked eye, **Intercellular Canals;** there are none of these structures present, **Fibres and Fibre-Tracheids;** no septate structures present in the fibres, the fibres are thick-walled, there are no fibre tracheids present, **Tracheids;** there are none of these structures present, **Rays;** the rays are less than 1mm in height and are a mixture of bi-seriate and tri-seriate rays, the ray tissue is homogenous and no aggregate rays are present, the bi-seriate rays are not wider than the uni-seriate rays, there are no tile cells present and the rays are not storied, pits to vessels are small, pits are similar in size and are less than 10μ in diameter, they are similar in shape to the intervascular pitting, **Parenchyma;** the parenchyma are predominately paratracheal (associated with the pores), and they are aliform in structure (wing-like lateral extensions surrounding the pores), **Miscellaneous Features;** there was no included phloem, axial elements storied, oil or mucilage cells present, **Crystals,** these were not present due to the antiquity of the slide material.

Material studied: FHOw 22606

Chapter 8 – The Commercial and Local Use of *Dipteryx odorata*

8.1 Products made from the timber of *Dipteryx odorata*

The *Dipteryx odorata* timber has been used for paving blocks, cogs and shafts, fishing rods (Fanshawe 1948), barge and dock fenders, flooring, industrial flooring, railroad crossties, pulp mill equipment, tool handles, bearings, turnery, (Hess *et al.* 1950, Brown 1977, Berni 1979, Chudnoff 1984), agricultural implements, in naval construction, boat building (frames and keels) (Kribs 1968, Brown 1978), civil engineering as beams, rafters, joists, planks, door frames, parquet, flooring boards, wooden panelling, stakes, support posts, double tee junctions, sleepers, furniture, (Rhodmann Hardwood Flooring 2002).

All these products made from *Dipteryx odorata* will be used in conditions that are harsh on the material, as it will be exposed to the elements or to a high amount of wear, such as bearings or industrial flooring. The wood has excellent weathering characteristics (Chudnoff 1984) and laboratory tests show the heartwood to very durable and resistant to both white and brown rot fungi (Hess et al. 1950, Chudnoff 1984).

Dipteryx odorata is also very resistant to attack and damage by the termite species *(Cryptotrmes brevis* (Walker)). When tested against 34 other Amazonian timber species, *Dipteryx odorata* ranked 30 out of 35 for overall resistant properties against this termite (Dolores *et al.*1982); the heartwood very resistant to chemical treatment (Berni 1979).

On two timber merchant websites, *Dipteryx odorata* is marketed as an 'Iron wood' with the other neotropical timber, Ipe (common name); commonly the genus of *Tabebuia* sp., family *Bignoniaceae*. *Dipteryx odorata* has gained this name due to its high natural durability. Build-Smarter Ltd. and Golf Course Traders claim that the wood needs no treatments or coatings to make it more durable, it only needs an oil-based sealer applied annually (Goodfellow Inc. 2002, Country Club Landscaping 2002). The durability and low maintenance of this wood are its main selling points for decking or outdoor uses.

Dipteryx odorata (or a trade name that is applied to this species) currently seems to be a popular wood for decking and parquet flooring, many websites can be found advertising the wood for these purposes, (Rhodmann Hardwood Flooring 2002, Aloha Hardwood Flooring 2002, Country Club Landscapes 2002, Exotic Hardwoods 2002, Goodfellow Inc. 2002, Somerset Hardwoods-Exotic Collection 2002, Buildsmater With Alternative Materials 2002, Smokey Mountain Hardwood Flooring 2002, Rare Earth Hardwoods 2002, Chesapeake Hardwood Products 2002).

The oily nature of the timber, its hardness and surface smoothness are major reasons that *Dipteryx odorata* makes a suitable timber were friction and abrasion in use will be a factor, for example as bearing, cogs and shafts (Brown 1977, Chudnoff 1984).

The timber is popular as an interior flooring material as it is hard-wearing, but also its seasoned colour makes it attractive (ranges from light brown to yellowish brown to reddish brown in colour, characteristically a streaky wood; Ducke 1943, Hess *et al.*

1950, Berni 1979, Chudnoff 1984) and it gives a good smooth finish to the product (Rhodmann Hardwood Flooring 2002, Exotic Hardwoods 2002, Rare Earth Hardwoods 2002, Smokey Mountain Hardwood Flooring 2002).

The timber is useful were good shock resistance and high bending strength are needed. Its hardness and oily nature makes it a suitable substitute for *Guaiacum officinale* (Lignum Vitae; Howard 1948, Rendle 1969, Chudnoff 1984), a timber that occurs naturally in the Caribbean islands and is declining in availability. *Guaiacum officinale*, is traditionally used for cogs and bearings were friction is a problem (Brown 1978, Chudnoff 1984).

8.2 Certification Status under the Forest Stewardship Council

A certification resource centre states 'that tapping the wealth of species from tropical forest can encourage conservation, by increasing the economic viability of use of these diverse ecosystem' (Certification Resource Centre – Lesser Known Species 2002). The reason for this statement is that in the harvesting of a tropical forest only a small proportion of the standing trees are commercially desirable. On the international market very few actual species or species groups are demanded, this is due to the conservative nature of the market to buy what they already know and have reliable supplies of. Many more trees in the forest have the same qualities or would make good substitutes but as they are not well to the trade there is less demand for them. Under the Forestry Stewardship Council (FSC), a part of their work is to promote lesser known species. The more species that have a value in the forest the more likely that sensitive harvesting (to distribution, species composition and age class) can be planned. If the value of the total standing timber is increased by lesser

known species finding a market, and the operations then have the potential to gain a better return per hectare.

In theory in sustainable harvesting practices this should provide and incentive to invest more in the planning and operations to achieve a sustainable harvest. Using a greater diversity of species to harvest stops the process of 'creaming' taking place within the operations, this is (one or a few species are consistently removed at the exclusion of the others) as they are the most valuable. On this site there are 10 timbers listed as 'lesser known species' (although only eight species are specified, the other two are references to genera only) *Dipteryx odorata* is being promoted under the name Cumaru as useful for decking, garden furniture and deck tiles. (www.forest certification.org 2002)

Only two companies (A. Van Den Berg B.V. and Ecotimber) in the UK that have FSC chain of custody certificates are able to supply certified *Dipteryx odorata* or *Dipteryx* sp. (Cumaru).

8.3 History of Trading of *Dipteryx odorata*

In 1943, Ducke reviewed some of the most important timbers of South America arguing that after the end of World War II the continent had one of the world's largest timber reserves that could be used for rebuilding and that trade in timber, although internationally non-existent at the time would be very important after the War. Ducke (1943) lists 27 potential species, of which *Dipteryx odorata* was one.

8.4 The Market Value of *Dipteryx odorata*

Cumaru is listed on the International Tropical Timber Trade (ITTO) annual tropical timber report 2002. The country of source listed is Peru, with the Asian market being cited as the most important destination for Cumaru hardwood flooring originating in Peru. Cumaru is sold as kiln-dried (KD) and as S4S (the timber is planed smooth on four sides). To the Swedish market it is valued at US$635-650 per cubic metre and the value to the Asian market is US$545-560 per cubic metre (ITTO Annual Report 2002).

From a questionnaire (Appendix 8.1), sent out to four timber exporting companies (DLH Nordisk, Inter-continental Hardwoods, Robinson Lumber, J.Gibson McIlvain) and four American-based importing companies (Columbia Forest Products, Eidai Industries, Moorland Company USA Ltd and Sitco Lumber .Co.) three replies were received.

Three replies were received from DLH Nordisk, the UK office replied only that they do not sell the timber in the UK. Replies from the office in Bélem and in Hong Kong, both stated that the company buys *Dipteryx odorata* timber under the name Cumaru and use this name to market it. The timber is also bought under the names 'Champagne', 'Cumaru Champagne', 'Ferro' and 'Cumaru ferro' in Brazil. At the Hong Kong, office only the genus name *Dipteryx* is known to be the scientific name for Cumaru, whereas in Belem the timber Cumaru is mainly *Dipteryx odorata* but other species may be mixed in with the lots that they buy. The main source of timber was given only as Brazil.

Both offices cited that the bulk of the Cumaru that was traded goes to China, with some decking going to the USA and France. The Brazilian office stated that they trade approximately 6000 m^3 per year, whilst the Hong Kong office indicated that the company traded 3000 m^3 per year. The end-use of the wood was for flooring, the timber is sold from Brazil as KD and S4S strips to China at a price of US$ 600-640 per cubic metre, and to Europe (France) they sell the air-dried (AD) rough-sawn timber at US$450 per cubic metre.

8.5 Local Use of the Timber

In 1948, Fanshawe cited that the timber of *Dipteryx odorata* is scarcely used locally, with Ducke (1940, 1943) commenting that the tree is commonly left standing in clearings, suggesting that the timber was of little importance locally.

However by 1977, Brown writes that there is extensive local use of the timber for bearings, cogs and shafts to replace the timber *Guaiacum officinale*.

8.6 Trading and use of the Seeds of *Dipteryx odorata*

Commercially, *Dipteryx odorata* has been very important for the production of its seeds that are source of coumarin.

Table 8.1 The table lists Industries that use *Dipteryx odorata* seeds and the source of coumarin they provide. The products of the different industries in which the coumarin is used.

Industry Used In	Used For What	Author
Tobacco	Flavour cigarettes	Nery (1901), Gonzalea Vale (1942), MacBride (1943), Howard (1948), Lamb (1962), Nakano *et al.* (1970), Brown (1978), Pesce (1985)
	Flavour cigars	Nery (1901), Gonzalea Vale (1942), MacBride (1943), Howard (1948), Lamb (1962), Nakano *et al.*(1970), Brown (1978), Pesce (1985)
	Flavour snuff	Nery (1901), Gonzalea Vale (1942), MacBride (1943), Howard (1948), Lamb (1962), Nakano *et al.*(1970), Brown (1978), Pesce (1985)
Confectionary	Vanilla substitute in cocoa production	Nery (1901), Brown (1978)
Medicine	Anti-spasmodic	Pesce (1985)
	Anticoagulant	Nakano *et al.* (1970)
Alcohol Flavouring	Vermouth	Lamb (1962)
	Whiskey	Lamb (1962)
Perfumes & Cosmetics	Scent soap	Nery (1901), Lamb (1962), Beauty Direct (2002)
	Scent shampoo	Nery (1901), Lamb (1962), Beauty Direct (2002)
	Scent perfumes	Nery (1901), Ducke (1940), MacBride (1943), Axtell *et al.* (1992), Lamb (1962), Nakano *et al.* (1970), Pesce (1985), Parrotta *et al.* (1995), Azevedo *et al.* (1999)
	Aromatherapy Oil	Beauty Direct (2002), Natural Solutions (2002)

The development of synthetic coumarin (Nakano *et al.* 1970) has lead to a decline in the importance of the tree for generating income from this non-timber forest product (NTFP). Although the coumarin derived from the seeds still has a use in the American tobacco industry (Axtell *et al.* 1992), and in perfuming soap and cosmetics (Beauty Direct 2002, Natural Solution 2002).

The species *Dipteryx punctata* and *Dipteryx trifoiliolata* also produce seeds that yield cumarin (Ducke 1943).

According to Pesce (1985), for commercial purposes, the seeds are classified according to their size and provenance, the highest quality seeds are said to originate from Venezuela, as they are the largest and command the highest price. Second-class seeds are smaller and come from the Guianas, the third-class seeds coming from Pará, Brazil. In Pará, the seeds are rated as third-class since they can be mixed in colour (yellow and black) and the crystallization process used to extract the coumarin in Pará is reported not to be as efficient as in other areas.

Demand has again risen as the seed is becoming popular as a flavouring for whiskey and vermouth and as a substitute for vanilla in sweet dishes (Pesce 1985). It is currently used as a vanilla-scent in cosmetic products and in aromatherapy oils. The seeds and oil are currently sold by Tropilab Inc, 125 ml of *Dipteryx odorata* based oil (Tonka oil) is US$10.50 and a packet of four seeds costs $4.00 (Tropilab Inc. 2002).

8.7 Local use and importance of the seeds of *Dipteryx odorata*

Dipteryx odorata has been cited to have the name Muimapagé (Lorenzi 1996) and Muirapayé (Kribs 1968) from Brazil, particularly from the states of Amazonia and Mato Grosso (Corrêa 1984). The literal translation of the name Muirapayé means tree of the witches, wizards or magic, the seeds of the tree are reported to be narcotic (Parrotta *et al.* 1995), it is perhaps likely that this tree has some importance to indigenous healers or shaman if the seeds induce a narcotic effect.

The communities of Jamaraquá, Marituba and São Pedro in the State of Pará, use *Dipteryx odorata (*referred to as Cumaru by these communities); a preparation using the seeds is made as a tea to treat pneumonia, sore throats and headaches one seed is

all that is required to make a tea, the yellow oil obtained from the seeds is used for cuts and abrasions (pers com. Mary Menton 2002).

Chapter 9 - Discussion

The main focus of this study has been the neotropical tree *Dipteryx odorata* and how the information that is available about it, can be related to find and establish its natural and cultivated distribution and to infer what habitat it exists in and the threats it is currently facing as a species.

The tropical humid forests in the neotropics are the most diverse forests in terms of species numbers. Currently many practices are threatening the loss of neotropical forests. Although it is realised that in these countries there has to be ways found that the forest resources can be used to benefit the people that live in the region, but also give the environmental protection that the forests safeguard locally and globally.

A system that is currently promoted is sustainable forest management, were the forest is utilised for either non-timber forest products (NTFP's) or for the harvesting of timber to provide an income. The main force behind sustainable forestry is to practice harvesting that is sensitive to the forest structure, composition and species that exist there.

A problem that is highlighted in the literature, is that due to the high species diversity of the humid tropical forests, making an inventory of species composition for timber harvestign, even just the commercial timber species is fraught with problems. The species diversity is so high that not all trees being felled have been described by

science. The majority of trees in the neotropics that have a use to man generally have a name associated with them, so a tree can be identified by a common name but this does not always give a reliable identification. Many different taxonomic species in the forest are given the same common name, if they have similar characteristics.

Where logging operations are trying to practice sustainable forestry they are finding problems in monitoring there species composition and loss due to logging activities, even with the species that are felled and removed from the forest, as it proves a problem in the field to reliably identify all the species present, some can just be previously undescribed.

From the literature review of the species it has 59 different common names and 59 differenet trade names applied to it. It is also has its vernacular or trade name in common with another different species. *Dipteryx odorata* is cited to be confused with 13 other different species, 7 are in the same genus *Dipteryx.* Andre Franco of DLH Nordisk in Belém (a timber exporting company) gave information that their hauls of timber bought as *Dipteryx odorata,* will sometimes contain timber of other species. Three genera were found to have the vernacular names in common with the genus *Dipteryx* were *Amburana, Poecilanthe, Taralea* and only two species of the genus *Torresa* .

Understanding where the likely distribution of the species can be might help to understand the changes that it is facing in its habitat. *Dipteryx odorata* is found to occur mainly in the humid tropical forests of the Amazonian Basin, extending into Panama and Costa Rica of Central America. It is also found in the Caribbean islands

of Martinique and Guadeloupe extending its range a further 6^0 north of Panama and Costa Rica (10^0). More evidence is needed to establish its occurrence in the Caribbean as the two common names appear only once for each country. It is found to reach its southern limit at 16.35^0 south in northern Bolivia.

Chapter 10 - Conclusions

Dipteryx odorata was found to be distributed in the countries of the Amazonian Basin, it extended its natural to long established range through Panama and the lower half of Costa Rica, it also occurs naturally on the windward islands of the Martinique and Guadeloupe.

The flower is thought to exhibit colour change at the time of post pollination, changing from rosy white through to a crimson purple colour.

The timber has a broad selection of common and trade names 88 in total were found. There are some species that are commonly cited as being confused with *Dipteryx odorata* they are *D.oleifera* and *D.trifoliata* .

This tree is cited as a lesser known species on the timber trade market but it has considerable popularity as a timber that is used for parquet flooring and decking.

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Appendix 4.1 - The table below gives information on the Herbarium samples from Missouri Botanical Gardens, New York Botanicals Gardens and Daubeny Herbarium, Oxford University.

Country	State	Location	Longitude	Latitude	Altitude	Specimen No.	Species Name	Herbarium
Ecuador	Napo	Yasuni	0.56S	76.13W	250	566	*Dipteryx micrantha*	Missouri Botanical Gardens
Colombia	Amazonas	Amaycayacu	03.02S	70.00W	100	4967	*Dipteryx micrantha*	Missouri Botanical Gardens
Colombia	Amazonas	Amaycayacu	03.02S	70.00W	100	5438	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Explorama camp	03.20S	72.55W	100-140	13526	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Puerto Almendras	03.28S	73.45W	122	17650	*Dipteryx odorata*	Missouri Botanical Gardens
Peru	Loreto	Explorama Lodge	03.28S	72.50W	130	42235	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Puerto Almendras	03.48S	73.25W	122	4779	*Dipteryx odorata*	Missouri Botanical Gardens
Peru	Loreto	Allpahuayo	03.50S	73.25W	130	55993	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Mishana	03.55S	73.35W	130	5322	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Allpahuayo	04.10S	73.30W	150-180	15166	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Loreto	Allpahuayo	04.10S	73.30W	150-180	14762	*Dipteryx micrantha*	Missouri Botanical Gardens
Venezuela	Bolivar		05.54N	62.16W	480	20620	*Dipteryx odorata*	Missouri Botanical Gardens
Peru	Loreto	Explorama Lodge	08.28S	72.50W	106	14093	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Ucayali	Coronel Portillo	08.41S	075.00W	270	31214	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Huanuco		08.49S	74.43W	350	1865	*Dipteryx micrantha*	Missouri Botanical Gardens
Brazil	Acre	Senador Guiomard	10.40S	67.46W		1018792	*Dipteryx odorata*	New York Botanical Gardens
Bolivia	Pando	Puerto America	11.36.07S	67.56.45W	211	2510	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios	Manu N.P.	11.52S	71.22W	400	43452	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios	Tambopata	12.49S	69.18W	280	45870	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios	Tambopata	12.49S	69.43W	280	51394	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios	Tambopata	12.49S	69.17W	260	5153	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios	Tambopata	12.49S	69.17W	261	5346	*Dipteryx micrantha*	Missouri Botanical Gardens
Bolivia	Santa Cruz	Huanchaca	13.53.41S	60.48.46W	500	431	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Santa Cruz	Huanchaca	13.55.34S	60.48.45W	500	73	*Dipteryx odorata*	Missouri Botanical Gardens

Country	State	Location	Longitude	Latitude	Altitude	Specimen No.	Species Name	Herbarium
Bolivia	La Paz	Buena Vista	14.22S	67.33W	180	166	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Santa Cruz	Chore	14.23.21S	61.08.47W	160	3131	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Beni	serrania del Pilon Laja	15.09S	67.31W	700-740	13980	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Beni		15.13S	67.03W	700-800	13278	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Beni		15.13S	67.03W	850	13864	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Beni	Santa Rosa del Isiboro	16.14.4S	65.14.5W		348	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Santa Cruz		16.32S	64.35W	170	9442	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Santa Cruz		16.35S	64.31W	180	9373	*Dipteryx odorata*	Missouri Botanical Gardens
French Guiana	Region de Saul	Commune de Saul	3.37N	53.13.0W		1004113	*Dipteryx odorata*	New York Botanical Gardens
Brazil	Acre	Tarauaca	8.17.38S	71.06.40W		230011	*Dipteryx odorata*	New York Botanical Gardens
Brazil	Para	Mipo de Oriximina				1683	*Dipteryx odorata*	Missouri Botanical Gardens
Bolivia	Beni					108	*Dipteryx micrantha*	Missouri Botanical Gardens
Bolivia	Pando				200	19649	*Dipteryx micrantha*	Missouri Botanical Gardens
Colombia	Meta	Parque Nacional Natural Tinigua				400	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios				380	27229	*Dipteryx micrantha*	Missouri Botanical Gardens
Peru	Madre de Dios				380	267754	*Dipteryx micrantha*	Missouri Botanical Gardens
French Guiana						1004114	*Dipteryx odorata*	New York Botanical Gardens
French Guiana	Saul					1004115	*Dipteryx odorata*	New York Botanical Gardens
Guyana								Daubeny Herbarium Oxford
Guyana								Daubeny Herbarium Oxford
Brazil								Daubeny Herbarium Oxford
Brazil								Daubeny Herbarium Oxford

Appendix 4.2 - Common names for *Dipteryx odorata* and the corresponding country were the name is used. If no country name it was not referenced in the literature.

Common Name	Country Were Name is Used	Author
Almendrillo	Bolivia; Bolivia (Beni)	Rico (1988); Killeen et al. (1993)
Almendrillo negro	Bolivia	Rico (1988)
Almendro	Bolivia (Santa Cruz); Brazil; Costa Rica; Panama	Wangaard *et al.* (1952); Chudnoff (1984); Killeen *et al.* (1993)
Amarello	Brazil, (Amazonia & Mato Grosso)	Corrêa (1984)
Bois de coumarouna	Martinique	Howard (1948)
Bois de coumarue	French Guiana	Lamb (1962)
Champange	Brazil	Lorenzi (1996)
Charapilla	Peru	Loureiro (1968); Chudnoff (1984)
Comarre	Suriname	Howard (1948)
Cuamara	Guyana	Howard (1948); Lamb (1962); Corrêa (1984)
Cumaru	Bolivia; Brazil, French Guiana, Guyana, Venezuela	Howard (1948); Nakano *et al.* (1970); Rico (1988); Axtell *et al.* (1992); Lorenzi (1996); Azevedo *et al.* (1999); Ribeiro *et al.* (1999)
Cumarú verdadeira	Brazil	Parrotta *et al.* (1995)
Cumaru amarello	Brazil	Howard (1948); Lorenzi (1996)
Cumaru de cheiro	Brazil	Lorenzi (1996)
Cumaru de fôlha grande	Brazil	Loureiro (1968); Lorenzi (1996)
Cumaru do Amazonas	Brazil; Brazil (Mato Grosso); Brazil (Manaus & Amazonia)	Howard (1948); Loureiro (1968); Corrêa (1984); Lorenzi (1996)
Cumaru roxô	Brazil	Loureiro (1968)
Cumarú	Brazil; Brazil (Mato Grosso & Amazonia); French Guiana; Guyana; Venezuela	Ducke (1939); Hess *et al.* (1950); Wangaard *et al.* (1952); Chudnoff (1984); Corrêa (1984); Parrotta *et al.* (1995)
Cumarú		Nery 1901; Macbride (1943); Pesce (1985)
Cumaru verdadeiro	Brazil	Corrêa (1984); Lorenzi (1996)
Cumarurana	Brazil	Lorenzi (1996)
Cumarut	Peru	Lamb (1962); Chudnoff (1984)
Cumarut ferro	Brazil	Lamb (1962)
Cumaruzeiro	Brazil (Amazonia & Mato Grosso); Brazil	Ducke (1940); Corrêa (1984); Lorenzi (1996)
Cumbarí	Brazil	Loureiro (1968)
Cumbaru	Brazil	Lorenzi (1996)
Desconocido		Spicherger *et al.* (1989)
Faux gaiac	French Guiana	Loureiro (1968); Corrêa (1984)

Common Name	Country Were Name is Used	Author
Faux gayac	French Guiana	Howard (1948)
Février tonka	French Guiana	Howard (1948)
Gaiac	French Guiana	Howard (1948)
Gaiac de guyane	French Guiana; Guyana; Venezuela	Axtell *et al.* (1992)
Gayac	French Guiana	Howard (1948)
Gayac de cayenne	French Guiana; Guadeloupe	Howard (1948); Loureiro (1968)
Gayac male	French Guiana	Howard (1948)
Gomorrow	Guyana	Howard (1948)
Groot locus	Suriname	Howard (1948)
Guayac	French Guiana	Corrêa (1984)
Koemaroe	Brazil; French Guiana; Guyana; Suriname; Venezuela	Hess *et al.* (1950); Wangaard *et al.* (1952);Loureiro (1968); Brown (1978);
Kumara	Guyana	Howard (1948)
Kumaru	Brazil; French Guiana; Guyana; Venezuela	Fanshawe (1949); Hess *et al.* (1950); Wangaard *et al.* (1952); Brown (1978)
Kumbaru	Brazil, Amazonia & Mato Grosso	Corrêa (1984)
Muimapagé	Brazil	Lorenzi (1996)
Muirapaye	Brazil	Kribs (1968)
Muirapayé	Brazil, Amazonia & Mato Grosso	Corrêa (1984)
Paru	Brazil, Amazonia & Mato Grosso	Corrêa (1984)
Quamare	Suriname	Howard (1948)
Sarrapia	Colombia; French Guiana; Guyana; Venezuela;	Howard (1948); Lamb (1962); Loureiro (1968); Nakano *et al.* (1970); Chudnoff (1984); Corrêa (1984); Axtell *et al.* (1992)
Sarrapio	Brazil; Colombia; French Guiana; Guyana; Venezuela	Hess *et al.* (1950); Wangaard *et al.* (1952)
Sarrapio	Colombia	
Sarrapio	French Guiana	
Sarrapio	Guyana	
Sarrapio	Venezuela	
Sarrapio	Venezuela	
Tonca bean	Guyana	Howard (1948)
Tonga bean	Guyana	Howard (1948)

Common Name	Country Were Name is Used	Author
Tonka		
Tonka		
Tonka		
Tonka		
Tonka		
Tonka		
Tonka		
Tonka bean	Brazil; French Guiana; Guyana; Venezuela	Howard (1948); Fanshawe (1949); Hess *et al.* (1950); Wangaard *et al.* (1952)
Tonka bean		Macbride (1943)
Tonka bean		Marenco (2001)
Tonka boon	Suriname	Howard (1948); Lamb (1962)
Tonkin bean	Guyana	Howard (1948)
Tonquin bean	Guyana	Howard (1948)
Yape	Venezeula	Corrêa (1984)

Appendix 4.3 Trade names for *Dipteryx odorata* and the corresponding country were they are used. If no country name it was not referenced in the literature.

Timber Name	Country Were Name is Used	Author
Almendrillo	Bolivia	Chichignoud *et al.* (2001)
Almendro	Belize; Costa Rica; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama	Chichignoud *et al.* (2001); Kribs (1968)
Baru	Brazil	Kribs (1968)
Barujo	Brazil	Kribs (1968)
Bois de coumarue	French Guiana	Kribs (1968)
Brazillian chestnut	Brazil	Botânica Madeiras Ltd. (2002);
Brazillian teak	Brazil	Botânica Madeiras Ltd. (2002); Rare Earth Hardwoods (2002)
Camaru		Boutelje (1980)
Camarurana	Brazil	Kribs (1968)
Cambaru	Brazil	The Brazilian Trade Center (2002)
Cambaru-ferro	Brazil	The Brazilian Trade Center (2002)
Cearensis		Exotic Hardwoods (2002)
Champange	Brazil	Andre Franco, DHL Nordisk, pers.com. (2002)
Champange		The Brazilian Trade Center (2002)
Champanha	Brazil	Chichignoud *et al.* (2001); Botânica Madeiras Ltd. (2002);
Charapilla	Peru	Kribs (1968); Chichignoud *et al.* (2001)
Charapilla		Boutelje (1980); Exotic Hardwoods (2002); The Brazilian Trade Center (2002)
Coco Feijao	Brazil	Kribs (1968)
Coumarouna		Howard (1948)
Cuamara	Guyana	Kribs (1968)
Cuamru	Brazil; Guyana	Kribs (1968); Chichignoud *et al.* (2002); Andre Franco, DLH Nordisk pers.com. (2002)
Cumaru		Howard (2002); Loureiro *et al.* (1968); Boutelje (1980); BMA Commodity Investment (2002); The Brazilian Trade Center (2002)
Cumaru amarelo		The Brazilian Trade Center (2002)
Cumaru champagne	Brazil	Andre Franco, DHL Nordisk, pers.com. (2002)
Cumaru da folha grande		The Brazilian Trade Center (2002)
Cumaru escuro		The Brazilian Trade Center (2002)

Timber Name	Country Were Name is Used	Author
Cumaru ferro	Brazil	Chichignoud *et al.* (2001); Andre Franco, DLH Nordisk pers.com (2002); The Brazilian Trade Center (2002)
Cumaru rosa		The Brazilian Trade Center (2002)
Cumaru roxo		The Brazilian Trade Center (2002)
Cumarú verdaderia		The Brazilian Trade Center (2002)
Cumarurana	Brazil	Chichignoud *et al.* (2001)
Cumarut	Peru	Kribs (1968)
Cumarut		BMA Commodity Investment (2002)
Cumbaru	Brazil	Kribs (1968)
Cumbaru ferro		The Brazilian Trade Center (2002)
Cunbari		The Brazilian Trade Center (2002)
Cunuru		Howard (1948)
Ebo	Belize; Costa Rica; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama	Lamb (1962); Kribs (1968); Loureiro (1968); Chichignoud *et al.* (2001)
Ebo		Boutelje (1980); Chudnoff (1984); The Brazilian Trade Center (2002)
Emburena brava	Brazil	Kribs (1968)
Faux gaiac	French Guiana	Kribs (1968); The Brazilian Trade Center (2002)
Feijao coco	Brazil	Kribs (1968)
Ferro	Brazil	Andre Franco, DLH Nordisk, pers. Com. (2002)
Gaiac	French Guiana	Kribs (1968)
Gaiac		Boutelje (1980)
Gaiac de cayenne	French Guiana	Chichignoud *et al.* (2001)
Gayac	French Guiana	Kribs (1968)
Gomorrow	Guyana	Kribs (1968)
Groot locus	Suriname	Kribs (1968)
Iron wood		Build Smarter With Alternative Materials (2002) Country Club Landscaping (2002)
Katoelimia	Suriname	Kribs (1968)
Kelappabosie	Suriname	Kribs (1968)
Koemaroe	Suriname	Kribs (1968); Chichignoud *et al.* (2001)
Komaro	Suriname	Kribs (1968)
Krapabosie	Suriname	Kribs (1968)
Kumaru	Guyana	Kribs (1968); Chichignoud *et al.* (2001)
Muirapage	Brazil	The Brazilian Trade Center (2002)
Pau cumaru	Brazil	Kribs (1968)

Quamary	Guyana	Kribs (1968)

Timber Name	**Country Were Name is Used**	**Author**
Roble		Exotic Hardwoods (2002)
Sarrapia	Colombia; Venezuela	Kribs (1968); Chichignoud *et al.* (2001)
Sarrapia		The Brazilian Trade Center (2002)
Shihuahuaco amarillo	Peru	Chichignoud *et al.* (2001)
Southern chestnut		Goodfellow Inc.(2002)
Tonka	French Guiana; Suriname	Kribs (1968); Chichignoud *et al.* (2001)
Tonka		Brown (1977,1978); Berni (1979); Boutelje (1980); Chudnoff (1984); The Brazilian Trade Center (2002)
Tonka bean		Lamb (1962)
Tonka bean	Guyana	Chichignoud *et al.* (2001)
Tonke bean		Boutelje (1980)
Tonkin bean	Guyana	Kribs (1968)
Yape	Venezuela	Kribs (1968)

Appendix 4.4 - names that are applied to the trade in seeds of *Dipteryx odorata*.

Seed Name	Country and/or Language Were Name is Used	Author
Angustura	Venezuela	Pesce (1985)
Dutch Tonka	French Guiana	Uphof (1968)
Dutch Tonka	Guyana	Uphof (1968)
Dutch Tonka	Venezuela	Uphof (1968)
Fava de cumarú	Portuguese	Corrêa (1984)
Fava de Tanha	Portuguese	Corrêa (1984)
Fava do India	Portuguese	Corrêa (1984)
Fava do tonkin	Portuguese	Corrêa (1984)
Féves de tonka	France	Tropilab Inc. (2002)
Féve de tonka	French	Corrêa (1984)
Koko Vanilla	USA	Natural Solutions (2002)
Rumara		Tropilab Inc. (2002)
Surinam	Guyana	Pesce (1985)
Surinam	Guyana	Pesce (1985)
Tonguin bean		Tropilab Inc. (2002)
Tonka bean	Brazil	Ducke (1940)
Tonka bean	Brazil	Ducke (1943)
Tonka bean	French Guiana	Axtell *et al.* (1992)
Tonka bean	French Guiana	Uphof (1968)
Tonka bean	Guyana	Axtell *et al.* (1992)
Tonka bean	Guyana	Uphof (1968)
Tonka bean	Portuguese	Corrêa (1984)
Tonka bean	USA	Corrêa (1984)
Tonka bean	Venezuela	Axtell *et al.* (1992)
Tonka bean	Venezuela	Uphof (1968)
Tonka bean		Brown (1977)
Tonka bean		Gonzalez-Vale (1942)
Tonka bean		Nakano *et al.* (1970)
Tonka bean		Nery (1901)
Tonka bean tree	USA	Corrêa (1984)
Tonka bohnen	Germany	Corrêa (1984)
Tonkabohne		Tropilab Inc. (2002)
Tonquin bean		Nery (1901)

Appendix 4.5 - Timber trade names that apply to *Dipteryx odorata*, with corresponding country or language in which it is used.

Timber Name	Country and /or Language Were Name is Used	Author
Bois de coumarouna	French	Corrêa (1984)
Camiri	Italy	Howard (1948)
Coumarounaholz	Germany	Howard (1948)
Cumary	Italy	Howard (1948)
Gaiacholz	Germany	Howard (1948)
Koemarie	The Netherlands	Howard (1948)
Kumaru	English	Corrêa (1984)
Tonca	English	Kirbs (1968)
Tonca	UK	Lamb (1962)
Tonca bean	UK	Howard (1948)
Tonga bean	UK	Howard (1948)
Tonguin bean	UK	Lamb (1962)
Tonka	UK	Lamb (1962)
Tonka bean	English	Kribs (1968)
Tonka bean	UK	Howard (1948)
Tonkin	English	Kribs (1968)
Tonkin bean	UK	Howard (1948)
Tonquin bean	UK	Howard (1948)

Appendix 6.1 - The species that are different from *Dipteryx odorata* but have vernacular names (common name) the same as a vernacular name applied to *Dipteryx odorata* and the country were the common name is used. (*Tropical Timber Center)

Species Name	Common Name	Country Were Name Used	Author
Amburana acreana	Cumaru do cheiro	Brazil	*Trop.Tim. (1975)
Amburana acreana	Cumarú de cheiro	Brazil	Ducke (1943)
Amburana cearensis	Cumaru do cheiro	Brazil	*Trop.Tim. (1975)
Andira inermis	Cumare	Brazil	Kribs (1968)
Andira inermis	Cumaru	Brazil	Kribs (1968)
Andira inermis	Cumarú rana	Brazil	Ducke (1940)
Apuleia molaris	Cumarú rana	Brazil	Ducke (1940); Macbride (1943)
Dipteryx ferrea	Cumarú ferro	Brazil	Ducke (1943); d'Olivera *et al.* (2002)
Dipteryx magnifica	Cumaru ferro		da Silva *et al.* (1977)
Dipteryx oleifera	Almendro	Costa Rica; Honduras; Nicaragua; Panama	Hess *et al.* (1950); Wangaard *et al.* (1952); Kribs (1968)
Dipteryx oleifera	Baru	Brazil	Kribs (1968)
Dipteryx oleifera	Barujo	Brazil	Kribs (1968)
Dipteryx oleifera	Bois de coumarouna	Martinique	Howard (1948)
Dipteryx oleifera	Bois de coumarue	French Guiana	Kribs (1968)
Dipteryx oleifera	Camarurana	Brazil	Kribs (1968)
Dipteryx oleifera	Charapilla	Peru	Kribs (1968)
Dipteryx oleifera	Coco feijao	Brazil	Kribs (1968)
Dipteryx oleifera	Comarre	Suriname	Howard (1948)

Species Name	Common Name	Country Were Name Used	Author
Dipteryx oleifera	Coumarouna		Howard (1948)
Dipteryx oleifera	Cuamara	Guyana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Cumaru	Brazil; Guyana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Cumaru amarello	Brazil	Howard (1948)
Dipteryx oleifera	Cumaru do Amazonas	Brazil	Howard (1948)
Dipteryx oleifera	Cumarut	Peru	Kribs (1968)
Dipteryx oleifera	Cumbaru	Brazil	Kribs (1968)
Dipteryx oleifera	Cunuru		Howard (1948)
Dipteryx oleifera	Ebo	Costa Rica; Honduras; Nicaragua; Panama	Hess *et al.* (1950); Kribs *et al.* (1968)
Dipteryx oleifera	Emburena brava	Brazil	Kribs (1968)
Dipteryx oleifera	Faux gaiac	French Guiana	Kribs (1968)
Dipteryx oleifera	Faux gayac	French Guiana	Howard (1948)
Dipteryx oleifera	Feijao coco	Brazil	Kribs (1968)
Dipteryx oleifera	Février tonka	French Guiana	Howard (1948)
Dipteryx oleifera	Gaiac	French Guiana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Gayac	French Guiana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Gayac de cayenne	French Guiana; Guadeloupe	Howard (1948)
Dipteryx oleifera	Gayac male	French Guiana	Howard (1948)
Dipteryx oleifera	Gomorrow	Guyana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Groot locus	Suriname	Howard (1948); Kribs (1968)
Dipteryx oleifera	Katoelimia	Suriname	Kribs (1968)
Dipteryx oleifera	Kelappabosie	Suriname	Kribs (1968)
Dipteryx oleifera	Koemaroe	Suriname	Kribs (1968)

Species Name	Common Name	Country Were Name Used	Author
Dipteryx oleifera	Komaro	Suriname	Kribs (1968)
Dipteryx oleifera	Krapaboise	Suriname	Kribs (1968)
Dipteryx oleifera	Kumara	Guyana	Howard (1948)
Dipteryx oleifera	Kumaru	Guyana	Kribs (1968)
Dipteryx oleifera	Muirapaye	Brazil	Kribs (1968)
Dipteryx oleifera	Pau cumaru	Brazil	Kribs (1968)
Dipteryx oleifera	Quamare	Suriname	Howard (1948)
Dipteryx oleifera	Quamary	Guyana	Kribs (1968)
Dipteryx oleifera	Sarrapia	Colombia; Venezuela	Howard (1948); Kribs (1968)
Dipteryx oleifera	Tonca bean	Guyana	Howard (1948)
Dipteryx oleifera	Tonga bean	Guyana	Howard (1948)
Dipteryx oleifera	Tonka	Suriname	Howard (1948); Kribs (1968)
Dipteryx oleifera	Tonka bean	Guyana	Howard (1948)
Dipteryx oleifera	Tonka boon	Suriname	Howard (1948)
Dipteryx oleifera	Tonkin bean	Guyana	Howard (1948); Kribs (1968)
Dipteryx oleifera	Tonquin bean	Guyana	Howard (1948)
Dipteryx panamensis	Almendro	Costa Rica; Nicaragua; Panama	Hess et al. (1950)
Dipteryx panamensis	Ebo	Costa Rica; Nicaragua; Panama	Hess et al. (1950)
Dipteryx polyphylla	Cumarururana		da Silva *et al.* (1977)
Dipteryx punctata	Cumaru		Chichignoud *et al.* (2001)
Dipteryx punctata	Cumaru amarello		da Silva *et al.* (1977)
Dipteryx trifoliata	Almendro	Costa Rica; Honduras; Panama	Kribs (1968)
Dipteryx trifoliata	Baru	Brazil	Kribs (1968)

Species Name	Common Name	Country Were Name Used	Author
Dipteryx trifoliata	Barujo	Brazil	Kribs (1968)
Dipteryx trifoliata	Bois de coumarue	French Guiana	Kribs (1968)
Dipteryx trifoliata	Camarurana	Brazil	Kribs (1968)
Dipteryx trifoliata	Charapilla	Peru	Kribs (1968)
Dipteryx trifoliata	Coco feijao	Brazil	Kribs (1968)
Dipteryx trifoliata	Cuamara	Guyana	Kribs (1968)
Dipteryx trifoliata	Cumaru	Brazil; Guyana	Kribs (1968)
Dipteryx trifoliata	Cumaru		Chichignoud *et al.* (2001)
Dipteryx trifoliata	Cumarut	Peru	Kribs (1968)
Dipteryx trifoliata	Cumbaru	Brazil	Kribs (1968)
Dipteryx trifoliata	Ebo	Costa Rica; Honduras; Panama	Kribs (1968)
Dipteryx trifoliata	Emburena brava	Brazil	Kribs (1968)
Dipteryx trifoliata	Faux gaiac	French Guiana	Kribs (1968)
Dipteryx trifoliata	Feijao coco	Brazil	Kribs (1968)
Dipteryx trifoliata	Gaiac	French Guiana	Kribs (1968)
Dipteryx trifoliata	Gayac	French Guiana	Kribs (1968)
Dipteryx trifoliata	Gomorrow	Guyana	Kribs (1968)
Dipteryx trifoliata	Groot locus	Suriname	Kribs (1968)
Dipteryx trifoliata	Katoelimia	Suriname	Kribs (1968)
Dipteryx trifoliata	Kelappabosie	Suriname	Kribs (1968)
Dipteryx trifoliata	Koemaroe	Suriname	Kribs (1968)
Dipteryx trifoliata	Komaro	Suriname	Kribs (1968)
Dipteryx trifoliata	Krapaboise	Suriname	Kribs (1968)

Species Name	Common Name	Country Were Name Used	Author
Dipteryx trifoliata	Kumaru	Guyana	Kribs (1968)
Dipteryx trifoliata	Muirapaye	Brazil	Kribs (1968)
Dipteryx trifoliata	Pau cumaru	Brazil	Kribs (1968)
Dipteryx trifoliata	Quamary	Guyana	Kribs (1968)
Dipteryx trifoliata	Sarrapia	Colombia; Venezuela	Kribs (1968)
Dipteryx trifoliata	Tonka	Suriname	Kribs (1968)
Dipteryx trifoliata	Tonkin bean	Guyana	Kribs (1968)
Dipteryx trifoliata	Yape	Venezuela	Kribs (1968)
Geoffroya inermis	Cumarú rana		Macbride (1943)
Taralea oppositifolia	Cumarú rana	Brazil	Ducke (1940)
Taralea oppositifolia	Cumarú rana		Pesce (1985)

Appendix 6.1.1. The two species below have the same trade name as *Dipteryx odorata*.

Species Name	Common Name	Timber Name	Author
Dipteryx oleifera		Almendro	Kribs (1968)
Dipteryx trifoliata		Almendro	Kribs (1968)

Appendix 8.1 – Questionnaire that was sent to timber merchants and timber exporters and importers.

Subject; *Dipteryx odorata, Cumaru*

Question 1;
1.Dose your company buy this timber species known as Cumaru?

Question 2;
2. What other names do you buy this timber under?

Question 3;
3. Under what name do you market the timber?

Question 4;
4. Which country does you main of timber supply come from?

Question 5;
5. How many cubic metres of this timber do you buy/sell in a year?

Question6;
6. What price per cubic metre do you sell it at?

Question 7;
7. What products is the timber sold as?