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Bioprospecting in Thai Forests: Is It Worthwhile?

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Abstract: Tropical forests contain countless possibilities for the development of useful products, but there are many impediments to the satisfactory utilization of these products. The tropical countries that have high natural biodiversity usually lack the scientific base and technology needed for the discovery and development of useful products. This problem has to be overcome by careful negotiation and collaboration. Another major problem is that random prospecting or screening of species from the tropical forest is found to be generally unprofitable for western institutions, due to the high expenses and high risk. The risk factor is due mainly to the low probability that any given species will yield a valuable product that will repay all the effort. In order to make bioprospecting more worthwhile, the screening process must be made more efficient. Various kinds of information may be used to increase efficiency, including leads from previous chemical and pharmacological research, indigenous human knowledge and traditional medicine, and ecological research on plant-animal interactions. Ecological research is best carried out on permanent biodiversity study plots established in protected conservation areas. Use of conservation areas is governed by special regulations, and bioprospecting in them will require clarification of sensitive legal and ethical issues.

INTRODUCTION

Tropical forests, which are home to approximately 50% of the species of organisms on the earth, are vast cornucopias of potentially useful foods, medicines, and useful chemicals. The tropical forests contain the cures for cancer and all the other diseases of mankind. As yet poorly known fruiting plants in these forests offer the potential of greatly improving the diet and nutritional health of mankind. Tropical forest areas are worth at least as much as equivalent areas of prime agricultural land in terms of the rich array of useful products that could be harvested from them.

Statements such as the above are now commonplace in the general news media as well as in books on conservation. Reputable scientists make such statements and are respected for it, even

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though the evidence to date does not support them in full. Often, the purpose of such statements is to exhort us to conserve the biodiversity of the earth before it is too late—the "use it or lose it" argument (ref. 1). Nevertheless, statements of the tremendous potential value of biodiversity to us are reasonable extrapolations of what we do know. A rich tropical forest does have thousands of species of plants and hundreds of thousands of insects and other small animals, and probably hundreds of thousands of fungi and microbes. And we know that these organisms manufacture great arsenals of chemicals for manifold purposes. Plants, for example, owe their continued daily existence to chemicals which are toxic to herbivores, inhibit their digestive enzymes, or are extremely difficult to digest. Twenty or thirty years ago it was controversial to claim that these chemicals were much more that accidental byproducts of metabolic processes, but now we accept their evolutionary importance as common knowledge. We know that plants can be induced to produce defensive chemicals when fed on by herbivores and, moreover, that a lot of energy is expended in producing them. Given the fact that relatively few organisms have been screened for useful chemicals, we have reason to believe that there is a tremendous number in the forest just waiting for us.

Screening for natural products in the forest has begun in earnest. In Thailand, many local researchers and institutions have become involved, although their assays are generally not as sophisticated as those used in large institutions in North America and Europe. But there is strong interest, because Thailand is a high biodiversity country with highly accessible tropical forests. Thailand, therefore, should be proud that the 15% of its land area that is now or soon will be included within protected conservation areas is an economically sound investment, in the long run, that will produce benefits that will repay all the management, protection and lost opportunity costs. The tropical forests and their products are the heritage of all mankind, and saving, managing, and using them will benefit all of us. This principle is embodied in the Convention on Biological Diversity formulated in Rio in 1992, and about to be ratified by Thailand.

But it will be a long time before the riches of the tropical forests, and the tropical coral reefs, are realized. Will species-rich tropical forests really compete successfully with agricultural and other destructive land uses in the market place, as Janzen (ref. 1) implores that they must? Many of us remain skeptical. But we have thought about it enough to realize that the major barriers to the realization of the value of the forests concern the economic and legal problems of properly defining ownership and use rights (ref. 2). The problem often is that the current residents and users of tropical areas, the legal owners of the areas, and the people with the biotechnological expertise—the key to unlocking much of the value—represent three different parties, and they have scarcely begun to talk with each other.

IMPEDIMENTS TO BIOPROSPECTING IN THAILAND

Unfortunately, most people in Thailand, as in many other countries, do not see their biodiversity-rich forests as the heritage of mankind. Many people do not even agree that Thailand should join the Convention on Biological Diversity, to which the government has committed itself primarily, it seems, because of diplomatic pressures and the carrots—the possibility of obtaining World Bank and other funding under the Biodiversity Convention. This fact will create impediments to foreign organizations and scientists who would like to share the biodiversity of Thailand for their own benefit and the benefit of mankind. Even with the Convention and enabling Thai legislation in

force, it will not be easy for foreign chemists to get their hands on bioproducts from Thai forests. Even with the widespread traditional use of medicinal plants in Thailand, and the many active local research programs, Thailand does not seem to be in a mood to realize the value of its tropical forests by exporting benefits to foreign countries, least of all rich technologically advanced countries. In this paper, I will briefly discuss the 'mood' of Thailand regarding the ownership and use of native biodiversity as I perceive it as a long term resident involved in conservation, and the various legal and administrative impediments to using it.

Assuming that workable arrangements can be made to insure that Thailand's biodiversity will benefit Thailand and not primarily foreigners, prospecting for useful chemicals will be impeded by lack of knowledge of what plants may harbor chemicals useful for some purpose, and how these might be obtained from the forest. The random screening of plants for useful properties is inefficient and may not repay the effort required (ref. 3). This screening can be made less random and more efficient in several different ways, at various stages in the searching process. I will discuss some methods for improving the efficiency of the search which depend on ecological knowledge of the role of species in the forest community. Many chemical compounds evolved as a result of the interactions between species in the community, and such knowledge could be useful in deciding where to look for such compounds.

Knowledge about ecological interactions, however, is not easily obtained and depends on long term research projects carried out at forest study sites. A considerable effort to collect and identify all plants must be made initially on a site before much ecological research can even be begun. Such knowledge, therefore, has a cost and will not be casually surrendered without careful arrangements.

Long term ecological research sites, or LTERS, as they are commonly called, must be established in secure areas where they can be protected and managed. This often means that they must be set up in protected conservation areas which, also, are the only forest areas left which are not degraded or harvested (unless, of course, the objective is to study the effects of harvest or degradation on biodiversity). Any research performed in a conservation area must conform to the policies and regulations governing the area. In Thailand, conservation areas were established (starting in 1962) and are still managed by the Royal Forest Department (RFD). The RFD, once concerned almost entirely with managing the harvest of wood, now devotes nearly all of its budget to the management of national parks, wildlife sanctuaries, nonhunting areas and watershed protection. It has therefore become the lead agency in implementing conservation in Thailand.

Additional hurdles face scientists who wish to carry out research in Thailand. For example, All researchers are required to submit an application to the National Research Council of Thailand (NRC) for prior approval, a process which may require up to six months. Also, if any research equipment needs to be brought duty-free into the country, or if specimens need to be taken out, clearance must be obtained from the Customs Department, a process that is usually a great headache, and at worst, impossible.

First, however, I will discuss some ways in which ecological research in conservation areas could be used to increase the efficiency of bioprospecting, and then I will discuss further the possibilities for overcoming some of the impediments.

THE EFFICIENCY OF DISCOVERY

Improving the efficiency of discovery of bioproducts in plants and other organisms means increasing the chance that a given species selected for assay will result in a useful compound. This may be done in a variety of ways, most of which are widely known. First, a bioprospector will select species that are relatives of others that have already yielded useful products. Some families and genera of plants are known to harbor chemicals of certain types. Several existing databases can be consulted to facilitate this effort. This approach, however, has its limits because it will overlook little known taxa that may harbor fundamentally new products.

A second and highly productive approach is to assay plants used in traditional medicine by local peoples, especially those that dwell in the forests. The native cultures have already done the initial screening, based on hundreds or perhaps thousands of years of crude trial-and-error experimentation. In Thailand, efforts by foreigners to obtain such knowledge are often resented, because it is felt that foreigners have no "right" to such knowledge, especially if used for commercial benefit.

A third approach is somewhat newer and more sophisticated. That is to use ecological knowledge of species interactions in the natural forest (or marine) community to yield clues about where to prospect for useful chemicals. This approach is the least developed thus far, and perhaps the most difficult, but I believe that it offers the greatest potential. What we are asking, basically, is why plants and other organisms have produced such chemicals in the first place, to put it in teleonomic words. If we can answer this question, we should be able to examine the interactions among the species in the community to obtain leads on where to expect chemicals to occur. One of the leading researchers in species interactions in tropical forests is Dan Janzen, who has already come up with many such leads (e.g., ref. 4).

Species interactions in tropical forests occur in endless variety, but most may be classed in a relatively small number of basic categories, such as: predator-prey relations, pathogen-host relations, herbivory of leaves and shoots (by tiny insects or large primates, deer or elephants), frugivory, seed dispersal by vertebrate guts, pollination, parasitism (by plants as well as animals), plant-mycorrhizal relations, competition for resources between species, mimicry, etc. Generally, the relationship between two or more species may be characterized as neutral, exploitative (or "unfriendly"), mutualistic (beneficial or "friendly"), or a mixture of these. "Friendliness" is not a mental attitude, but a reckoning of how the relationship affects the reproductive fitness of the individuals involved, which will determine how natural selection should drive their "coevolution", or the reciprocal adaptations and counteradaptations of the species. This kind of evolutionary logic will suggest to us when and where organisms are most likely to produce chemicals that antagonize or neutralize other species, or products that might benefit other species (such as nectar, or succulent fruits).

As an example, consider the relations among fruiting plants, attacking insects, and seed dispersers. Succulent fruits appear to be "designed" to benefit dispersers which will swallow the seeds and carry them away. The seeds will survive passage through the gut and will likely have improved chances for germination. However, the fruiting plant needs to protect and nurture the seeds and surrounding fruit through a long period of development. This may mean covering the fruit with a tough rind or hard cover filled with noxious sap to prevent infection by pathogens, or insect repellents, and loading the seeds with poisons to deter seed predators (animals that eat and kill seeds such as beetles). If we know enough about both biology and chemistry, maybe some day

we will be able to predict what sorts of compounds would be stored in fruit rinds and seeds and when, and what kinds of uses we might make of them. When gibbons and monkeys eat large succulent fruits, they rip off the outer rind with their canine teeth before eating the inner pulp. At least one Thai fruit, the mangosteen (*Garcinia* sp.) has a rind which has yielded products marketed in a facial cream and skin conditioner. There are wild mangosteen species in the forest with more noxious and copious sap in the rind, and there are hundreds of fruit species whose rinds or covers have never been extracted.

In using ecological knowledge to help in bioprospecting, we need to ask many more questions about the nature of interactions between species, for example:

- How does the phenology of trees and shrubs relate to their need for chemical defenses in leaves?
- At what time during development is the need for chemical defense of seeds and fruit rinds the greatest?
- Do animals such as monkeys and apes use plant parts for their medicinal effects? What parts? How can we detect such use?
- How does the normal rate of growth of seedlings relate to their need for chemical defense?
- What animals rely on taste in selecting the proper fruits or leaves? How would this affect the need for both repellent and attractive compounds?
- How does the habitat and the form of fungal fruiting bodies affect their need for chemical defenses?

Searching for chemicals in plants must involve selecting not only the right species, but also the appropriate plant part. Plants are not homogeneous bags of chemicals. Should we extract the roots, new leaves, old leaves, fruit rind, pulp, aril, seed, growing shoots or bark? All of these parts have different functions and different palatability to herbivores, and different production costs. We might also need to decide what is the best time to harvest the part for assay, and in what microenvironment to collect the plant. As our knowledge of ecology grows, selection should become less chancy.

THE USE OF PROTECTED CONSERVATION AREAS

Advantages for research

Virtually all of the remaining closed canopy forests in Thailand are contained within the protected area system of national parks and wildlife sanctuaries, especially those that are still rich in animal species. Thai laws prohibit any form of hunting, trapping, commercial collecting, logging and encroachment in parks and sanctuaries, and they are protected by armed guards and rangers. These areas contain the communities that need to be studied in order to find out more about plant-animal relations and other interactions between species. The areas are relatively secure from disturbance, at least near the local Forest Department headquarters and guard stations. In several protected areas, permanent LTERS are being established to study plant ecology and interspecific relations. This author is establishing one in Khao Yai National Park mainly for the study of gibbon

(*Hylobates lar*) diet and ranging behavior and seed dispersal. The establishment of this plot involves survey of the area into 20-m square quadrats, and tagging, mapping and identifying every tree over 10 cm in dbh, within a 25-ha area, mostly using a standard methodology that has been worked out in other LTERS (ref. 5). A 25-ha area of tropical forest contains on the order of 12,000 trees over 10 cm in diameter, so that the task is a very time consuming one that can only be done with modern database technology.

The Royal Forest Department promotes tourism in the national parks, and encourages research in all protected areas. Accommodations are usually provided to researchers free of charge. Permission for scientific collecting of most organisms (birds and mammals usually excepted) may be granted by the head of the Forest Department. Recently, a wildlife research committee has been set up in the department to screen proposals submitted by the increasing numbers of prospective researchers, both Thai and foreign. Thus, it would seem that the protected conservation areas would be the most suitable places in which to carry out ecologically based searches for useful products.

The ownership and use of biodiversity

The is nothing in the legislation establishing or governing protected conservation areas which suggests that these areas were to be used or protected for their commercial values. Since the Royal Forest Department already owned the areas as reserved forests, it was simple to simply proclaim them as conservation areas for the protection of wildlife and watersheds and for the enjoyment of the people. Some financial benefits, however, were sacrificed by removing them from commercial concession areas. Thus, the conservation forests do not compete against other uses such as conversion to agriculture. Although poaching and minor encroachment are recurring problems, as well as some overdevelopment, the areas are generally well protected against massive encroachment and conversion. Tourism in the areas is still largely subsidized and is not required to offset management costs. The value of the biodiversity in development of useful products and chemicals is a use which has never been recognized or entered into the justification for saving the forests. Thus, the “use it or lose it” argument has little relevance to protected area conservation in Thailand.

The RFD has been generous in allowing research in its protected parks and sanctuaries, because such research is seen as contributing positively to management of the areas and in supporting tourism and educational use of the areas. Bioprospecting for useful chemicals, however, contravenes the laws which established protected areas in Thailand, as it represents a kind of harvest of products. Bioprospecting in conservation areas is not encouraged, but may be permitted if the benefits are seen to go to Thai people, and if the local plant populations are not threatened. A few incidents have occurred which indicate that the RFD would strongly oppose and not permit bioprospecting by foreign or multinational pharmaceutical companies. The common perception in Thailand, as elsewhere, is that such activity is a selfish profit-driven activity that will primarily benefit the people of the rich countries. The superior expertise, technology and efficiency of foreign companies in developing products is not considered, nor the fact that the growing members of the Thai middle class (including Forest Department officials) are turning more and more away from use of crude traditional medicine and embracing “western” scientific medicine.

The local perception of the Biodiversity Convention tends to be negative. Lawyers, for example, claim that its language is too vague, and that there is not sufficient Thai legislation if force to prevent exploitation of the country. Another group which opposes ratification is represented by the Institute of Thai Traditional Medicine under the Ministry of Public Health, which is attempting to organize traditional folk practicioners to keep their knowledge alive. The following statements, attributed to this institute (ref. 6), illustrate the degree of paranoia that has been spawned by the Convention:

"Under the 1992 Convention on Biological Diversity, any country possessing biological resources must accommodate researchers from other countries by providing them with information and allowing them to obtain specimens for study.

"Thailand stands to lose considerably more than it gains. With their money and technology, foreign countries and companies can send researchers in to study the medicinal values of our forest herbs and patent them as pharmaceutical products.

"We just hope that the Parliament doesn't pass it [the Convention]. If they do, foreign researchers will be able to take natural resources from our national parks quite easily.

"Forestry authorities, though, are waking up. In some forest reserves such as Thaleban National Park, only common Thai names are used to describe trees for visitors. Officials say that the scientific names are omitted in order to prevent foreigners from easily taking advantage of indigenous resources."

In fact, Thailand is already losing its indigenous resources. The Convention, if used properly, would permit Thailand to capture some of the benefits that it might not otherwise obtain.

It is ironic that harvest of traditional medicine by local collectors continues illegally in most conservation areas. Sometimes this involves considerable destruction of plants, such as the felling of trees or stripping off of their bark. The forest plant product harvested on the largest scale is probably the tree *Aquilaria crassna*, which produces *mai hom*, or aromatic wood. This product, known also as gharu wood or eaglewood, has been harvested throughout South and Southeast Asia for centuries,. The wood in the tree core which has apparently been darkened by a fungal exudate, after being burrowed through by insects, is distilled and yields an oil of some sort which is used in soaps, shampoo, body oil and other aromatic products. High quality darkly-stained wood collected from the forest is sold to a network of middlemen who market it to shops. Several dozen shops sell *mai hom* and its products in Bangkok, mostly on and around Soi Nana off Sukhumvit road. The trade has been so lucrative that the RFD has been completely ineffective in stopping the poaching in its protected areas. Now, most of the wood in Bangkok shops is said to come from Cambodia and Burma.

Under the Convention on Biological Diversity (and as reiterated in the Phuket Declaration adopted by the IUPAC International Conference on Biodiversity and Bioresources – Conservation and Utilization, 1997), the sovereign rights of states over their bioresources are fully recognized, and agreements for the cooperative utilization of such resources which benefit all parties concened, are to be encouraged. Under the Convention, arrangments should be made for the regulated search for bioproducts in conservation areas which will benefit Thailand as well as countries supplying their expertise in product identification and development. Such arrangements will beneficially involve local research institutions and scientists, and could also be designed to benefit protected area management if particular needs were identified.

There exists some illicit prospecting in conservation areas, some of it reportedly involving foreigners in collaboration with local villagers or other persons. Such illegal use of conservation areas brings no benefits from collaboration with foreigners. The purpose of providing for legal access to conservation areas under the Biodiversity Convention would be to permit Thailand to obtain increased benefits from foreign developers and users, not to allow exploitation by foreigners. But if the RFD refuses to consider such proposals, it will become an agency which by default allows illegal exploitation, while not permitting use which benefits Thai people.

ADMINISTRATIVE RESTRICTIONS

Any foreign person seeking to carry our research in Thailand of any type is required to apply for permission from the Foreign Researcher Section of the National Research Council of Thailand (NRC). The NRC can facilitate obtaining a visa from the Police Department, and can also facilitate arrangements with local researchers and institutions. In fact, the NRC requires the researcher to collaborate with a host institution, and will also submit any proposal for working in protected conservation areas to the RFD for approval. The RFD also now requires any researcher intending to work in a protected area to obtain prior clearance from the NRC, which provides a mechanism for the NRC to enforce its policies. Although the NRC can thus facilitate the researcher's project, it also serves as a screening mechanism. Any Thai researcher or institution that strongly objects to the project for any number of reasons can get the the NRC to reject the proposal. It thus behooves the prospective researcher to collaborate with, rather than compete with, Thai researchers, and be careful about removing specimens or other materials from the country without good justification.

THE NECESSITY FOR COLLABORATION

Is there any hope for a foreigner or company to work productively in Thailand legally? Is there any hope for foreigners to legally obtain products? At present, it is not easy to remove any products legally, but there are certainly excellent opportunities for productive collaboration. Prospective prospectors and procurers should probably wait until Thailand can ratify the Convention and set up a workable system for negotiating with foreign countries and companies. But Thailand is a congenial, friendly, and interesting place in which to work, and most institutions seek foreign collaboration. There is a growing capacity to search for and screen natural compounds in several local institutions. It is imperative to foster a good working relationship with a strong host institution, which can be invaluable in helping the researcher deal with other agencies such as the NRC, RFD, Customs, Immigration, etc. For the IUPAC, the most important objective should be to seek ways of increasing our *knowledge* about biodiversity through mutually beneficial collaboration. There are few impediments to this.

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