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THE ROLE OF THE IMPRACTICAL

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by William W. Sanford

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THE ROLE OF THE IMPRACTICAL

by

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Inaugural Lecture delivered at the University of Ife,
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A FRIEND of mine, who is a botanist in another university, once told me a family anecdote that has a bearing on my subject. His infant son was playing in the yard with the neighbouring children.

"What does your father do?" they asked him.

"He's a botanist," the child said.

"But what does he *do*?" they insisted.

"Oh, he plays with flowers."

It was a long time ago that I heard this story, and I was much younger then. I responded to it rather snappishly by saying, "So many people think that's all a botanist does!"

"But it is!" said my friend. "And a very good thing to do, too."

I am no longer ashamed of admitting that I play with flowers. In fact, I publicly confess that I play especially with one kind of flower that is often, in Western society, considered the symbol of luxury, the orchid. Most people would not consider this a very practical occupation, and some would think it shockingly impractical that I should be allowed to follow it in Africa. For this reason it would perhaps be appropriate if I examined this occupation from the standpoint of its impracticality, both to clear my own mind and to give you a chance to make up yours as to whether or not it is worth-while.

By practical in science I mean directly applicable to the wants or needs of man, as opposed the "pure" or "fundamental", which is not directly concerned with wants or needs. Before we weigh these two approaches, we must determine to which of the two the study of orchids belongs. I will begin by outlining the ways that orchids directly satisfy human wants or needs.

The first written reference to orchids (Withner 1959) dates from between 551 and 479 B.C. This is the remark of Confucius that acquaintance with good men is like entering a room full of fragrant orchids. The Chinese, and slightly later, the Indians, Ceylonese and Japanese have for a very long time treasured flowers much like some contemporary cultures treasure beautiful clothes and others beautiful automobiles. By the end of the Yuan Dynasty (1279-1368 A.D.) there was already a segment of Chinese painting exclusively devoted to the painting of orchids; and treatises on orchids, on their beauty, on ways of growing them and on their spiritual value appeared in Chinese as early as the Sung Dynasty (1260-1279 A.D.). To a culture which values orchids as aesthetic and spiritual objects, playing with orchids is a very practical and worth-while occupation, much like making clothes or automobiles or holy images for the church. Unfortunately, flowers were never considered this way in Western cultures.

The orchids were so named by the Greek botanist-philosopher and disciple of Aristotle, Theophrastos, 370-285 B.C., from the Greek word *orchis*, meaning testes, in reference to the paired underground tubers that many of the Mediterranean orchids have. The Ancient Greeks, like the people of the East, considered orchid lore practical but not for aesthetic or spiritual reasons: they thought that the tubers were powerful aphrodisiacs. I hasten to add that while many cultures today still value aphrodisiacs, there is no pharmacological evidence for any orchid being of practical use for this purpose. It is true, though, that some peoples of East Africa use the stems of *Ansellia gigantea*, an orchid also common in northern Nigeria, as an aphrodisiac (Breyer-Brandwijk 1962). Rather disturbingly, some peoples in southern Africa use the stems of the same orchid as a cough remedy.

The Europeans and Americans had a very different view of orchid use from that of the Eastern peoples. They were concerned with medicinal applications. The first written American reference to orchids is in an Aztec herbal of 1552 A.D. Early European references of the 15th and 16th centuries also occur in herbals. One is tempted to draw probably very unfair national comparisons on the basis of orchid use: aesthetic and spiritual pleasure in China from at least the 5th century B.C.; social use in Greece from about the 3rd century B.C.; medicinal applications in Europe and America from perhaps the 15th century A.D. Towards the end of the 18th century Europeans discovered that orchids were beautiful and at once began taking such large quantities of them from tropical Asia and America that these countries have never recovered botanically, and many species of orchids have become very rare or even extinct.

In tropical Africa, few orchids have local names which indicates that few have uses. Such orchids as do have names have uses which suggest that Africa may lie between the aesthetic East and the medicinal West. In Gabon, for example, the Fang people use the roots of an orchid for the strings of one of their loveliest musical instruments. In Nigeria, the Yoruba people formerly considered one orchid particularly pleasing to the god Ogun and planted it on *Dracaena* trees and at village shrines. A scattering of orchids in all African cultures has been used in medicine. One, *Eulophia angolense*, is used, in an area near Oyo, as a charm to protect little girls.

Today it is, however, almost exclusively as ornamental objects that orchids have become economically important and therefore practical in many cultures. They are grown for cut flowers by florists and as tropical and glasshouse plants by garden hobbyists. Centres of world production are Hawaii, Singapore, U.S.A., Europe, and, to a lesser but still significant extent, Kenya and Australia. One commercial firm exports flowers of horticultural hybrids from Ivory Coast. Orchid growing is so important to the economy of Hawaii that the botany/horticulture department of the university there is engaged almost exclusively in orchid research. Rather fortunately, few Africa-occurring orchids are obviously showy; had they been, they probably would have been removed to Europe in the 19th century. There is now, however, with changing fashion and the increase of specialized hobbyists, considerable world-wide interest in African orchids. We have had requests for West African species from every continent in the world. So far, we have exchanged only a very few species with five botanical gardens, because

I feel deeply about conservation. I believe it is man's duty to think very carefully before he endangers the continued existence of some living creation such as a plant or an animal. As I have written elsewhere (Sanford 1970), I realize that not every product of evolution can be maintained or else the world would be cluttered with ineffective and perhaps relatively useless organisms, much as cities become cluttered with ghettos and slums if they are not continually destroyed and rebuilt. But until the science of ecology is much more sophisticated than it is today in evaluating ecosystems (the more or less balanced and integrated systems made up of plants, animals, micro-organisms and the non-living factors of the environment such as light, water, soil) and in determining how much change a desirable ecosystem can withstand without disorganization, until we are able to do this, it is foolish to destroy anything not obviously harmful. For this reason, I take pleasure in rescuing plants from certain death in timber-felling areas and either growing them myself or sending a few to be grown in botanical gardens. Thus, as long as culture lasts in London, Hamburg, Vienna, Singapore and Budapest there will be West African orchids in these cities.

After a new ecological display house for orchids and other special plants is built in the Biological Gardens at Ife, the present collection of about 4,000 West and Central African orchid plants can be consolidated and improved. Then there will be time to rescue local, doomed-to-die plants from timber exploitations, land being cleared for agriculture, road building and university beautification projects, to exchange with botanical gardens for interesting foreign plants.

Medically, orchids have been somewhat of a disappointment to contemporary scientists. The most likely type of medically important compounds to search for in the orchids are the alkaloids. In 1966, H. Aluyi, then a third year student, and I carried out preliminary tests for the presence of alkaloids in sixty-one species of Nigerian-occurring orchids. We concluded that at least 26 percent of those tested contained significant amounts of alkaloids (Aluyi 1966). Word of this work reached Professor Lüning, a biochemist in Copenhagen, who asked us to cooperate with him in a search for alkaloids. From our extractions of the Nigerian ground orchid, *Liparis nervosa*, Lüning chemically isolated and characterized a new alkaloid, the aromatic part being 4-hydroxy-3, 5 diisopentenylbenzoate with an amino-alcohol, lendelofidine, and a sugar attached (Lüning: in prep.).

Besides alkaloids, orchids may be a reservoir of other organic compounds. The genus *Vanilla*, five species of which are found in West Africa, has long been grown in Central and South America as a commercial source of the flavoring vanillin, which is a coumarin derivative. Practical exercises at the University of Ife have indicated that West African orchids may also be interesting from the standpoint of phenolic compounds, products of so-called secondary metabolism derived via the shikimic acid and acetate pathways. With cooperation from the Faculty of Pharmacy this area may be explored.

When it comes to the immediate and direct gratification of human wants and needs, we have seen that orchids are practical as objects of aesthetic and spiritual enjoyment, as objects of recreation, i.e. in gardening, and as the source of Vanillin. It is also likely that they may prove to be sources of several alkaloids and possibly of interesting, if not immediately useful, phenolic compounds. A few special uses such as providing the strings for musical instruments and protecting pretty little girls—or attracting pretty bigger girls—may also be cited. But all of this does not come to an impressive total, unless one lives in Hawaii where orchids beat all other cash crops except pineapple. We obviously are not in Hawaii; I have already said that few African orchids are horticulturally sensational, and our university collection of West African orchids, while unique, is not primarily directed towards giving either pleasure or spiritual uplift to the general public. In spite of close cooperation with the Faculty of Pharmacy, I doubt if we will discover many chemicals useful in medicine or as commercial materials. I must admit, then, that playing with orchids in Africa is an impractical pursuit; that orchid study belongs to the impractical, basic or fundamental branch of scientific research. We may now inquire of what importance it is to man. This inquiry brings to mind another anecdote, this time, a zoological one. Professor Hans Kalmus, visiting geneticist at the University of Ife several years ago, once remarked, "I will have great hope for the future of science in any country where I see little boys collecting butterflies".

His point was that science grows out of curiosity about and enjoyment of one's environment. Such a view may be thought of a rather impractical and luxurious approach to science, as it requires that the individual practitioner have enough security, economic and emotional, to do what he enjoys, largely because he enjoys it. On the other hand, such an approach to science may be thought of as strictly practical, even necessary, because scientific accomplishment is so difficult and so rare that few, if any, can manage to work hard and well enough to achieve it unless they love their work. While scientific accomplishment requires love, the converse is not true: love of work is no guarantee of successful accomplishment. Furthermore, someone may be found to love almost anything, so that love of orchids, for instance, not only is not enough to ensure success with orchids, but there is no *a priori* reason why love of orchids is a good thing.

Again, we are back almost where we started. While admitting that love of work is a necessary and therefore practical prerequisite to scientific endeavour, be it applied or basic, we cannot say that arousing love of work is a function of the impractical simply because we have impractical lovers. We must try to evaluate the impractical, the basic, on more concrete grounds. The role of basic research has often been stated as the search for truth—perhaps something more concrete than love—and some philosophers, from at least as early a time as that of Plato, have insisted that truth and goodness are synonymous and that the only worthwhile purpose of living is to search for the good and the true. Another view has grown up in industrialized societies: that man can never find all truth, if indeed he can find any; therefore, with limited time, ability and energy, man must choose to search for only certain bits or kinds of truth. This view when projected onto the corporate body of society means that a community or a culture will tolerate many truthseekers of some sorts, few truthseekers of other sorts and none at all of still other sorts.

I was reminded of this when, two years ago, I spent some time at the National Herbarium of Vienna in which is housed the 19th century dried plant collection of Reichenbach, one of the three or four most famous orchid scholars of all time. I had been working for several hours, sitting in his armchair, too, when the curator came by and said, "We have not had a specialist in African orchids here for over fifty years!" I replied, "One every fifty years is enough isn't it?"

He said, "Yes".

If we accept that there is not a need for the same quantity of all kinds of truth-seekers, we still have the problem to solve of what is the use, if any, of my particular and rare kind.

Basic research may also be considered from a purely utilitarian standpoint: while applied research is directed towards the solution of a single, specific problem and if successful will solve only a single, specific problem, basic research if successful will provide general knowledge which can in turn be used in solving a number of specific problems as well as in furthering the search for still more general knowledge. In this way, basic research is often in the long run more economical than is applied research. My impractical playing with orchids may, then, be an avenue of truth-seeking which, while not a necessary one for many men, might be necessary for a few men and might have as an aim the finding of general truth that is applicable not to orchids alone, or to any one specific problem, but is applicable to many plants and to many problems. But if we accept the contemporary industrial dictum that not all general truth is of value, then we need to explore precisely what kind of general truth orchid research is concerned with. It is in this abstract field that I must now wander.

When discussing the abstract and the general, it is easier to begin with the specific and concrete. I had better begin by trying to inform you what orchids are—something that up to now I have avoided doing, because I felt that their identity had no practical importance so long as we were discussing them as practical objects. Now that we are discussing them as subjects of general inquiry, as mechanisms for getting at general truths, it becomes imperative to know quite a bit about them.

The Orchidaceae is a family of monocotyledonous flowering plants which probably arose in the Cretaceous period in Malesia, perhaps something like 50,000,000 years ago, and has since spread to every continent of the earth except those areas perpetually covered with ice and snow. Plants are considered to belong to this family if they possess a number of characteristics in common, including the unusual feature of completely fused filaments (carriers of pollen-bearing anthers) and styles (carriers of stigmas) into a single structure called the gymnostemion or column; reduction of pollen-bearing anthers to one or two, reduction of the female receptacle, the stigma, to one; the production of hundreds of thousands of extremely minute seeds which contain no stored food (endosperm) and no differentiated tissue (embryo) but are composed of only c. 80 to 200 cells more or less like each other. The flowers of these plants are made up of two whirls of showy segments, the outer one containing three sepals usually much like each other, the inner one of three petals, one of which is usually markedly different in size, colour, and shape. This odd third petal is called the labellum or lip and may be modified into innumerable strange shapes, all the way from tubular spurs 30 to 40 centimeters long to shoe-like pouches in which insects are made drunk or mad. Some lips are such effective mimics of female insects that the males try to copulate with them. Every known colour of the visible spectrum is represented in the orchid flower, and under ultraviolet light, fluorescent patterns appear.

There is considerable argument as to how large this extended family is. Hunt counted the valid specimens in Kew Herbarium and arrived at about 17,000 species in 750 genera (Hunt 1967). Garay, at Harvard University, on the other hand, counted the original diagnostic type descriptions and arrived at 30,000 species.* My own view is that if a thorough, modern revision could be made of the orchid family, we would end up with about 15,000 species. This means that about 7% of the flowering plants of the world are orchids. The bulk contribution to the flora of the world alone gives orchid study some claim to importance, and thus one aspect of orchid study becomes orchid identification: we cannot describe the plant cover of any part of the earth intelligibly unless we can identify the orchids we encounter. Not all regions of Africa have yet been catalogued and provided with means of identifying the plants occurring there. Kew is at present working on such a flora for East Africa, and the National Museum of Natural History in Paris, in cooperation with the government of the Republic of Cameroun, has asked me to do the book on orchids for the Cameroun flora series, which will cover the 400-500 species found there. Kew published a flora for the orchids of West Tropical Africa in 1968 which includes Nigeria (Summerhayes 1968). Like most orchid floras, I fear that this one is very much a specialist's book in the sense that even the professional botanist does not often use it to identify orchids but rather sends his specimens to an orchid specialist for determination. You can imagine the difficulty there is, then, in the identification of orchids for agriculturists, foresters, ecologists and nature lovers. Many of us feel that this situation must and can be

* Leslie Garay (1970): personal communication.

remedied. I am, therefore, working on a volume for the *Flora of Nigeria* series, which I hope will make possible the identification of most of the more than 400 orchid species found here for almost anyone who is really interested. Incidentally, the editorial board hope that the *Flora of Nigeria* will eventually update and supercede the *Flora of West Tropical Africa* and bring the problem of the taxonomy and identification of African plants back where it belongs—to Africa.

It may be well at this time to ask what is the purpose of identifying orchids other than cataloguing them as plants of a region? The orchids that are used as research objects in the search for general truth must be identified so that other scientists, both now and in the future, can know precisely what the research material was and so perhaps repeat the experiment to test the results or apply the findings to other plants and other environmental situations. For this reason, a specimen of any plant, orchid or not, that is used as a test object for published research must be deposited as a voucher specimen in a herbarium that is recognized by the International Association for Plant Taxonomy at Utrecht. The University of Ife herbarium has been so recognized for four years and is internationally coded IFE; I believe the only herbarium code name in the world which is also the complete location name.

In summary, we must be able to accurately identify orchids so that we can describe the vegetation of the world precisely and so that we can use orchids as research objects. This now brings us to what the purpose of research on orchids may be. In order to know this, we need to know something of the special peculiarities of these very strange plants.

One of the odd things about them is their nutrition. As has already been remarked, the seed contains no stored food. In order to develop into a seedling it must be supplied with carbohydrate as well as with water, oxygen and minerals. Under natural conditions, the tiny, dust-like seed must imbibe water, swell and be invaded by the hyphae of fungi. A complex fungal-plant tissue association is then formed, the mycorrhiza. The fungal components now digest cellulose from bits of dead plant material, most often wood, and the sugars so formed are then transported to the orchid cells. At the same time, it appears that the hyphae facilitate transport of water and minerals. There is very recent evidence that somewhat later the orchid begins to synthesize materials needed by the fungus so that some mutual assistance occurs (Arditti and Robert 1972). Such a situation is not confined to orchids, but is surprisingly common in forest trees of the tropics, so that playing with orchids from this standpoint brings information applicable to trees. The orchid, soon after fungal invasion, begins to synthesize fungal-inhibiting chemicals called phytoalexins. The existence of such "antimycotics", now known to occur in a number of plants, was discovered about seventy years ago, and the discovery was made in an orchid plant. The phytoalexins control hyphal growth so that the orchid continues to be benefited without being damaged or destroyed. Knowledge of this odd situation of containment has led to the very interesting area in crop protection, of research on naturally produced substances of plants which effect resistance to fungal and bacterial attacks.

To return to the orchid seed: after it has developed a fungal association, cell divisions of the seed occur so that an onion-shaped mass of tissue, the protocorm, from 1 to 2 mm. in diameter, is formed. Chlorophyll develops, as do absorptive root-like structures. The organism can now make it alone, although the fungal association normally continues, even into adulthood. Still later, roots and leaves develop and a seedling results. This pattern of development involving undifferentiated cell proliferation, then complex differentiation, offers a unique opportunity for the study of basic growth phenomena. Long ago, on the Ibadan site, we were able to show in classroom work that the seeds of an African *Angraecum* could be kept proliferating cells indefinitely with little or no differentiation. This type of thing has since been utilized in so-called "meristem culture", whereby bits of shoot or leaf meristem, as well as the seed which may be thought of as pure meristematic tissue, are kept proliferating and periodically fragmented until from one tiny bit, or from one dust-like seed, several hundred or several thousand cell masses are formed. Then, differentiation is allowed to occur, and we have several thousand genetically indentical plants. This is now done on a commercial scale for orchids, and experiments are under way to apply the technique to various fruits and vegetables. Even more important, a great deal has been and is being learned about basic cell proliferation and differentiation, and about the effects of various wave lengths and intensities of light, gravity disorientation, O_2 tensions and chemicals on these processes. Some of this research is sponsored by cancer foundations because of the implications for basic cell behaviour.

Orchid seeds can be grown into seedlings without fungal invasion in aseptic cultures, provided that all minerals and a suitable carbon substrate are supplied. This offers a wonderfully precise way of studying the nutritional requirements of plants. A related area of particular interest, on which I have already done preliminary work with one of my students, is the possible presence of natural inhibiting and/or stimulating substance in tree bark and leaf leachates. These may, under natural conditions, control the epiphyte load in the tropical forest. (An epiphyte is a plant which grows upon another plant but does not take any of its nourishment from the living tissue of that plant. About 50% of the orchids occurring in Nigeria are epiphytes.) The possibility of population control by natural leachates was mentioned for orchids as long ago as 1940 (Went 1940) but has only very recently become a burgeoning general field of research, concerning inter-relationships of all plants and called "allelochemy" (Whittaker and Feeney 1971). So far, we have some evidence that phenolic compounds in the barks of some otherwise highly suitable host trees prevent or reduce the establishment of epiphytes. We have also found extremely interesting quantitative differences in sugars in barks of different tree species. (Falode 1971). The technical work of preparing aseptic culture flasks, innoculating them with sterilized orchid seed, transferring the seedlings and so on, requires considerable time and manual skill. Partly for such technical reasons, I am now collaborating with another botanist and a chemist in the United States of America who will do the microbiological work, while my students and I will be concerned with the trees, the bark and the overall ecology of the trees and their epiphytes.

So far, we have seen that orchids offer uniquely practical means of exploring host-fungal relationships, cell proliferation and differentiation mechanisms, organic and inorganic plant nutrition, and allelochemy. Besides these basic areas, another peculiarity of orchids opens up an even wider area of research.

As we know, evolution proceeds by mutation and genetic recombination followed by sexual isolation of the new forms so created. The usual breeding mechanisms, which prevent the new forms from being swamped by back-crossing onto the parental types are: structural and chemical incompatibility, and geographical or ecological isolation. The orchids are peculiar in that most often isolation is achieved through pollinator specificity instead of through the usual mechanisms. Orchids can almost never fertilize themselves but must have a transfer of pollen by insect from one flower to another. It is the uniqueness of the insect which can fertilize only a particular kind of orchid flower which isolates that flower sexually. In most orchids, then, the usual isolating mechanisms do not develop, because they are unnecessary; so that if we transfer the pollen manually from one flower to another, thus by-passing the specific pollinator, we can often obtain viable seeds when we cross different species and even when we cross different genera. In fact, so many hybrids can be and have been formed within the orchids that this family has played a major role in the breakdown of the Linnean system of classification, and its replacement by the Biological concept of Species. Because orchids can be so readily crossed, and because they have been horticulturally popular in Europe and Asia for some time, records of man-made orchid hybrids have been kept since 1854, a situation absolutely unique in the plant world.

Using these records together with my own crosses, I analyzed crossability among seven genera of tropical American orchids involving about 500 species. Manual analysis, followed by approximate spatial placement of the genera, together with a number of species, resulted in an ordination indicating probable genetic and evolutionary relationships, based as nearly as possible on the Biological concept of Species (Sanford 1964). Subsequent very different work by others in the areas of chromosome analysis and morphological/anatomical studies have shown remarkable agreement in affinities with these placements. Scientists at the 7th World

Orchid Conference in April 1972 felt that this approach would be especially useful if continued on a larger scale, with computer-aided analyses of the accumulated breeding records for other groups of genera. There is no other similar opportunity to put the Biological concept of Species to such practical test.

Unfortunately, no breeding of West African orchid species has been carried out so that no such records exist for them. Thus, a field that is interesting both horticulturally and scientifically is the hybridization of African species to produce commercial forms, to discover the genetic affinities between them and to investigate possible affinities with orchids of other continents, especially the Vandaceous orchids of Malesia, which have a number of anatomical/morphological similarities with the Angraecoid orchids of Africa. Such work would require laborious test-tube culturing of seeds and five to seven years of waiting for each cross to flower, so this project may depend upon students of the future. Meanwhile, Dr. Sowunmi of the University of Ibadan, her postgraduate student, Mr. Oyede, and I are cooperating on a numerical approach to relationships in African orchids. They will do palynological studies on all species, and then we will combine these results with morphological data and analyze through multivariate techniques. I estimate that once the research is completed, about eighty million mathematical calculations should give us an informative picture of all West African orchids—we may restrict our study to *some* West African Orchids!

Very general and basic concepts of geographical factors affecting plant dispersal as well as concepts of evolution are involved in such work; and these do not concern only orchids but all plants. A question which pertinently unites these basic concepts is that of the place of the tropics in evolution. It has been commonly held that the tropics are the germinative centres of speciation. While an attempt has recently been made to question this so far as animal evolution is concerned (Van Valen 1969), I know of no careful data analysis for plants, and can only say that I have indirect evidence plus an intuitive feeling that it *is* true that the tropics have been and still are evolutionary centres for plants. This begs the fascinating question, Why?

An attempt to explore this question leads one to attempt precise characterization of the tropical environment and the tropical plant community. It is with this rather expanded area of orchid play that I am now largely concerned. One part of this study is assessment of species diversity in the tropics together with assessment of the significance of such diversity. On one side, there is the question of whether or not all plant communities follow the Margelef (Odum 1967) model for micro-organisms of increased species and biochemical diversity, accompanied by decreased productivity, as the ecosystem reaches climax, or stability. If we accept that it is ecosystems which evolve as systems, rather than individual organisms which evolve, this progression towards decreasing productivity is a seeming paradox, at least when viewed anthropocentrically. In nature, this is perhaps compensated for by the increased stability of the system, so that if productivity were measured over long time spans—and nature's time is long—the overall production might be greater, because the system had kept intact as a system, withstanding the ever-occurring perturbations that are found even in nearly optimal tropical environments. A major factor of this increased stability, which allows a system to endure in spite of vicissitudes, is species diversity.

Another interesting problem associated with species diversity is the question of how so many genetically similar plants can exist together without genetic swamping or without ecological elimination through competition. This situation again is especially pronounced in the tropics. The solution to the genetical part of the problem is breeding isolation. Besides pollinator specificity, which we mentioned before, variation in blooming time may be important. If members of a closely related population vary enough in blooming time so that they cannot usually interbreed but that occasional overlap allows some gene exchange, we have a stable but heterozygous population. In my study of two years ago (Sanford 1971) I found that about 66% of the West African epiphytic orchids flower during one fairly consistent period of the year, 21% during two or three periods and 13% over a long and variable period. At least 35% of the epiphytes and perhaps at least 27% of the terrestrial ones seem directly day-length controlled, even though day-length variation is little at our latitude. Furthermore, about 13% of the epiphytic species appear to include genetically controlled variant forms that bloom consistently at different times from the normal or "wild" species type. I also found evidence for influence of temperature fluctuation. These results indicate a varied, multidimensional control of blooming that generally favors population stability but leaves the door open for occasional gene exchange. I believe this is the general picture for forest and woodland plant communities in the tropics.

The occurrence of so many different kinds of plants over such a small spatial area such as over a few square feet in a tropical forest or, in the case of epiphytic orchids, along one limb of a tree, besides posing the genetic problem of breeding isolation, poses the ecological one of species competition. A crucial question is whether or not such a community is at climax, or steady-state. According to older views, still prevalent, if the micro-community were at climax, all but one most successful kind of plant would be eliminated. A more recent but somewhat controversial view is that even a very small area actually represents a number of micro-habitats different enough from each other that a different species is best fit for each, so that considerable species diversity is found in a small area. A still more recent view is that several kinds of plants can actually exist in equilibrium in the same microhabitat (niche). I incline to the latter hypothesis; it presents the intriguing puzzle that you can prove it possible mathematically (Pielou 1969) and thus can never prove that such equilibrium does not occur in nature, but no one has yet been able to prove that it actually occurs.

The whole area of describing vegetation precisely enough to compare one place with another place, and the same place at different times, is very troublesome. And very vital. We need to be able to do this in order to assess what kinds of vegetation, what ecosystems, we have; which ones we want; in fact, which ones our continued existence depends upon; and how to maintain them over time. The most difficult of all vegetation to describe is the tropical, not only because most ecological work has been done in the temperate zones, but also because tropical vegetation is more complex. The problems of species diversity and apparent multi-habitation of the same niche contribute much to this complexity. One of the most astonishing things about studies in tropical ecology is that while the trees may be loaded with orchids, these plants are never mentioned, or if mentioned, they are referred to only as "epiphytic orchids". And yet they are among the most specialized of all plants as regards habitat, and so are potentially among the most precise indicators of environmental conditions. For example, being epiphytes with exposed roots as well as leaves, they are especially sensitive to moisture availability, which is the basic determiner of plant, and thus animal distribution, over much of the tropics. The reason why such potentially useful plants have not been used in ecological studies is pitifully simple: ecologists cannot identify them and orchid taxonomists do not know enough modern ecology to make use of them. Being neither an ecologist nor a taxonomist but rather only a botanist who plays with flowers, I have a certain advantage here.

I began using orchids in a modified Braun-Blanquet way to characterize orchid associations that were in turn associated with tree species, other non-woody plants and with environmental conditions (Sanford 1969). This was a very good approach for trying to learn some of the 1,000 to 1,500 species of trees found in Nigeria and the perhaps 8,000-9,000 herbaceous plants, but it was not highly productive ecologically. It is interesting, however, that a paper now in press by another worker, who is an ecologist, cites this early orchid work as relevant to the distribution of sedges, grass-like plants very different from orchids, in Nigeria (Hall 1973).

Being eager to test the usefulness of orchids as ecological characterizers in more precise ways, I compared mathematically 31 large sites, some up to 100 square miles in area, scattered over Nigeria in regards to the 114 species of epiphytic orchids enumerated over these sites. (The site enumeration of the orchids began in 1964 and owes much to the help of my wife, who is not only a good bush driver, but an expert identifier of West African orchids.) On the basis of these comparisons, the sites were arranged in space, that is ordinated along 2 or 3 axes, using with some modifications the geometric methods of Orloci (Orloci 1966). The resulting ordinations were remarkably informative; much more informative than comparable ordinations using tree species. Some of the environmental information which could be abstracted from, or related to, these orchid ordinations were: general vegetation types with more detail and precision than indicated by presently available vegetation maps of Nigeria (Keay 1959; Charter 1972); length of dry and rainy seasons; annual rainfall; one-peak or two-peak rainy season; biotic disturbances; major tree species (Sanford 1972; 1973).

Ordination in the other direction, that is through comparing the orchid species on the basis of the sites where they occur, gives very interesting ecological and distributional information on the species and genera, and may allow the detection of particularly useful indicator species—species associated with specific levels of certain environmental factors (Sanford 1973).

The expansion and refinement of this work is my most immediate concern. And somewhat surprisingly associated with this is the problem of weeds. The most useful definition of weeds, I believe, is that they are plants not purposefully planted which, in any particular geographic region, occur exclusively or almost exclusively in areas disturbed by man, where they form large contagious or nearly contagious populations. With the continued expansion of man and his use and improvement of the earth, it is not much of an exaggeration to say that weeds will be the only natural vegetation of the future. Orchids, in a precise sense, behave like weeds. Weeds colonize open communities; that is, communities where there are empty spaces. In the case of epiphytic orchids, the open communities are the barks of trees, especially towards the canopy; in the case of weeds and many terrestrial orchids, the open communities are the fields, burned-over grasslands, roadsides, and university grounds created by man's activity. The study of genetic systems, morphological and physiological characteristics and dispersal mechanisms of plants which make them successful colonizers, more successful competitors with their own kind than with other species, is another branch of playing with orchids, and one that encourages play with weeds as well.

It is by now probably fairly obvious that I have made up my mind that orchids at this time in this westernized culture are not directly of much practical use to man. It is also obvious that I have come to believe that the study of orchids may be of considerable impractical use to man. I have mentioned that, as objects of basic research, they are particularly suited for providing knowledge in the areas of plant nutrition, plant cell proliferation and differentiation, theoretical taxonomy, genetics and evolution, theoretical ecology, particularly problems of species diversity, ecosystem stability and productivity, competition and multi-species equilibria. Lastly, I have touched upon the use of orchids as general environmental charcterizers and, because of their behaviour, as study subjects related to weeds—the plants of the future. I have perhaps neglected the area which most concerns me. As I consider myself primarily a teacher, I use orchids as teaching mechanisms. As actual objects of study they can be used to illustrate most aspects of botany, whether they ultimately refer to yams or to lichens. Furthermore, by forcing me into so many different study areas, orchids have forced me into some degree of preparedness for the continually unexpected directions of student curiosity.

All in all, I might close with a remark from an orchidologist friend of mine, a plant physiologist, who said, "Anything you can do with a plant—you can do better with an orchid". *

* Joseph Arditti (1972) : personal communication.

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