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COLLECTING DATA AND SPECIMENS
FOR STUDY OF ECONOMIC PLANTS

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Collecting Data and Specimens For Study of Economic Plants

BY W. ANDREW ARCHER

Botanist, Office of Foreign Agricultural Relations

INTRODUCTION

Persons engaged in field work, especially in foreign countries, have a unique opportunity to make valuable contributions to the scientific and practical knowledge of agricultural crops as well as wild-plant products. These contributions may be pressed specimens for identification of the plants, material for study of plant diseases and insect pests, plant products for analysis, and seed or other material for propagation. Good photographs or reports describing economic plants, crops, and agricultural practices add greatly to the value of specimens. The purpose of this pamphlet is to instruct interested persons in proper methods of gathering, preparing, and shipping such specimens. It is essential that specimens be carefully prepared and that the information accompanying them be complete and accurate.

Only rarely can a satisfactory answer be given to inquiries about some native plant when nothing more is known than its local or vernacular name. A native name for a plant in a foreign country may not have any more significance than would a common name in the United States. A plant called "brown daisy" in one State may well be known as "blue-eyed marigold" in another. In Latin American countries, also, the common name of a plant often varies from one locality to another. For this reason, the local name is not a sufficient clue to the botanical identity of a plant. Likewise, people often send in a single leaf, a piece of stem, or a root only to learn that small fragments are inadequate. Botanists need a sufficient portion of a plant, with flowers or fruits, sometimes both, in order to identify it and to assign the correct botanical name. The specimen must be pressed flat and dried before shipping. Fresh plants wrapped in oilpaper for mailing usually arrive completely decayed. A plant tucked into an envelope arrives in a shriveled condition or else shattered to bits. The best method of assuring safe shipment is to protect the dried specimen with two pieces of stout cardboard.

Insect and diseased-plant specimens, as well as analysis and propagation material, also must be adequate in quantity, properly prepared, and carefully packed. Fungi and insects should never be shipped from one country to another while still alive, unless specifically requested by specialists; and in that event special arrangements would need to be made to conform with the quarantine laws of the countries concerned.

Samples of plant products for analysis, in most cases, would be collected only by special request. To remember this is important, because as yet the United States Government does not have a central laboratory for receiving and testing great quantities of food, drug, poison, or economic plants of other types. Previous arrangements would need to be made with some particular person or office to carry on such studies.

Likewise, propagating material, living plants, cuttings, or seed should not be sent without assurance that the shipment will be received and given proper care. Furthermore, strict regulations in many countries govern the import or export of living-plant material. These regulations are designed to prevent the dispersal of dangerous diseases or insects which might be carried by the plants.

In a number of Latin American countries, foreigners are required to secure a special permit to collect natural-history specimens, and these countries usually expect to have a duplicate set of the collections deposited with an official agency.

REMARKS ON FOREIGN TRAVEL

A collector planning a trip into distant countries has two sources from which to secure information about modes of transportation and conditions of living. He may ask questions of someone who has been in the countries, and he can read books relating to the area to be visited. The remarks in the present work apply mainly to Latin American countries and are by no means complete.

A recent handbook by Graham and O'Roke¹ gives excellent advice about out-of-door life in general. The collector going to Latin America will find many helpful publications; some cover the region as a whole and some individual countries.²

For any trip into a strange country, the area to be covered and the time to be spent there are essential considerations, but most important is the matter of equipment and supplies. Everything that will be needed must be listed, and the lists repeatedly checked as to completeness and quantities. A person who has not done any camping out had better seek the advice of an experienced hand. One cannot afford to make mistakes or take chances. Vilhjálmur Stefánsson, in one of his books on the Arctic, has made the sage statement that any explorer who has an adventure can lay it to his own carelessness.

The rules for traveling, living, or camping out are much the same for all countries: Learn all you can before starting; keep the itinerary flexible to allow for unpredictable changes; keep the luggage as light as possible; limit the party to the personnel actually needed, especially for long trips; purchase supplies and equipment, insofar as possible, in the country where the trip is to be made, in order to get what best conforms to the conditions of the region; get physical condition checked, with particular attention to eyes and teeth, before any extended trip; by all means learn

¹ GRAHAM, S. A., AND O'ROKE, E. C. ON YOUR OWN; HOW TO TAKE CARE OF YOURSELF IN WILD COUNTRY . . . 150 pp., illus. Univ. Minn., Minneapolis. [1943.]

² A partial list includes the following: For Latin America as a whole, UNITED STATES BUREAU OF FOREIGN AND DOMESTIC COMMERCE. COMMERCIAL TRAVELERS' GUIDE TO LATIN AMERICA. Trade promotion Series No. 122, Ed. 4, 616 pp. 1931; for Venezuela and Colombia, McDONALD, N. THE ORCHID HUNTERS . . . 294 pp., illus. New York and Toronto. 1939; for the Amazon region and Brazil, WALLACE, A. R. A NARRATIVE OF TRAVELS ON THE AMAZON AND RIO NEGRO . . . 541 pp., illus. London. 1853; GUENTHER, K. A NATURALIST IN BRAZIL . . . 399 pp., illus. Boston and New York. 1931; for Nicaragua, BELT, T. NATURALIST IN NICARAGUA . . . Ed. 2. 403 pp., illus. London. 1888; and for Bolivia and the Amazons, MCCREAGH, G. BLACK WATERS AND WHITE. 404 pp., illus. New York and London. 1926.

the language of the country; and, lastly, know thoroughly and comply strictly with the customs of the people encountered.

Anyone accustomed to fixed transportation schedules must be prepared for disappointments, and for this reason the itinerary should be planned to allow for alternative modes of travel. One should be prepared to travel by air, train, automobile, boat, canoe, horse, mule, or even by foot, depending upon circumstances or emergencies.

Naturally the kind and amount of luggage will depend upon the purposes of the trip, the mode of transportation, the length of time to be spent, and other factors. Nevertheless, the luggage should be confined to bare essentials. He who travels lightest often travels farthest. Usually much of the ordinary equipment, such as hammocks, blankets, mosquito nets, saddles, and cooking gear, can be obtained locally and will then conform with local needs and usage. Packing cases, of wood or leather, and duffle bags are often available in larger cities. Pressed-fiber cases are extremely desirable for their durability and lightness but cannot be bought in Latin American countries. In the United States they are usually made by special order and design. Separate pieces of luggage, weighing 50 to 60 pounds each, are better than one heavy unwieldy box, especially if travel is by horse or mule.

A collector's chief concern is the safety of his specimens and notes, and he should take every precaution to protect them. When traveling by canoe in rough country the containers of specimens and notes should be constructed with air chambers to ensure floating in case the canoe overturns.

Unless firearms are needed to hunt game for food, they might better be left at home, because they are likely to arouse suspicion and understandably so. This is particularly true when passing examination by the customs officials of different countries.

Usually a small exploring group is better than a large one, especially where transportation is uncertain. A party of 2 or 3 might travel with facility where a group of 10 to 15 would create a local crisis. Furthermore, people with mixed interests traveling together usually end up at odds with each other. The man wanting to collect plants will be held back by the one collecting insects or studying soils, or vice versa.

Clothing is a matter to be judged by the individual, but in most Latin American cities suits can be made to order rather cheaply. Since dry-cleaning service is obtainable only in larger cities, suits should be of washable material. White cotton suits are worn everywhere, except in the higher altitudes. Ready-made clothing usually is not available; consequently, the traveler might better stock up on field clothing at home. Khaki or blue-denim work trousers are appropriate and serviceable. Field shirts can be blue, khaki, or white, although the last are subject to stains and discoloration by plant juices. Shirts having two pockets with buttoned-down flaps are most practical. A pair of canvas leggings are useful when riding horseback. Travelers wearing hats larger than size 7, or shoes and socks larger than 10½, will do well to outfit themselves before leaving home, because large sizes in these articles are difficult to find.

Clothing brought from one's own country may not always be appropriate in the region to be explored; therefore, native materials and garments should be adopted as far as possible, on the assumption that they are best adapted to local conditions. As an example, the woolen ponchos (ruanas) of the highlands of Colombia and Ecuador can be

cited which are used as a protection against cold and rain. An ordinary raincoat would be unsuitable. On the other hand, if one were traveling in the Amazon Basin, in British Guiana, or Surinam an umbrella would be more in keeping with local custom and climate. In most of Latin America one must not expect to need field clothes only, because to be acceptable and presentable while in town one must appear in clean clothes, including coat and tie, regardless of the weather. Here one must watch carefully to see what the local conventions demand. It might be proper to appear on the street without a coat or tie, but usually one is expected to wear them when partaking of meals, even in small villages. In fact, a waiter may refuse to serve a guest who is improperly garbed according to local standards.

The choice of headgear will be governed not only by personal preference but also by local usage. In some parts of Latin America, only the poor people use straw hats; those better off financially wear felt hats. In some places (British Guiana) a sun helmet is inconspicuous, because everybody has one; but the same headgear elsewhere (Amazon) might appear quite ridiculous to the populace. In fact, the use of such a hat might even cause offense on the pretext that the wearer was intimating that the local sun was dangerous to health.

The question of field shoes also must be decided by the individual. Much depends, again, upon the type of country to be visited. For mountainous or rocky terrain, some collectors prefer heavy shoes with hobnails. The hobnails might, however, prove to be dangerous for climbing over smooth, or slippery, rocks. In such places, rubber-soled tennis shoes, or high-topped shoes of moccasin type with composition soles, will give better footing. The same advantage can be had with ordinary shoes by nailing small strips of bicycle tire to the soles. Many collectors prefer to wear heavy, laced, or riding, boots, but in humid climates the feet will become hot and uncomfortable in them.

The food in out-of-the-way places may not always be palatable, and the collector who expects to travel for as long as 8 months, in regions where a balanced diet is impossible, will do well to carry a supply of vitamin tablets in order to prevent deficiency diseases, such as beri beri. Sometimes a wise precaution is to have an emergency stock of concentrated foods, such as powdered milk, desiccated soup cubes, or pemmican.

Medical and dental examinations are essential just before leaving on an extended trip. Any special remedies and medicines can then be prescribed by the doctor. Certificates to prove recent vaccination against smallpox and inoculations for typhoid are required everywhere, and a number of countries demand similar certificates for yellow fever. Some travelers also take injections against tetanus and typhus.

The ordinary small first-aid kit will be sufficient for most short trips and should always be carried. A small first-aid manual is also valuable. Additional medicinal supplies and remedies will depend upon the length of the journey, the kind of travel, the nature of the country, and other circumstances. Special chlorine tablets are indispensable when the purity of drinking water is questionable, and some sort of remedy for dysentery should be on hand. If one carries a snake-bite kit, he should make certain that the antivenom is specific for the snakes of the country to be visited. Actually the danger of being bitten by a dangerous snake is remote. The average person thinks of the Tropics as a region swarming with deadly snakes ready to attack the unwary traveler; but, as a

matter of fact, one may travel for months without seeing a snake, and even then it is likely to be harmless.

The greatest danger results from the prevalence of insects, especially mosquitoes, which transmit a number of diseases. When in malarial districts, quinine or a synthetic substitute should be taken as a preventive. Some authorities recommend 10 grains of quinine daily, 5 in the morning and 5 at night. Medicines and doses for specific purposes should be prescribed, however, by a physician.

Various kinds of insecticides and repellents exist, but the most effective, developed recently for use of the armed forces, are not yet available to the general public.

At night, nets furnish the best protection against mosquitoes, but the nets supplied by most hotels and hostels of tropical America are usually torn and unserviceable; for this reason, the traveler will do well to carry his own. Small light nets, measuring about 8 ft. long, 4 ft. wide, and $3\frac{1}{2}$ ft. high, can be made to order of bobbinet having a mesh of 24 by 24 per square inch. A foot-wide hem of muslin at the bottom serves to tuck under the mattress. The edges also are reinforced with muslin, and each top corner is fitted with two tie strings. In regions where hammocks are used, specially shaped nets will be needed, but usually these can be purchased locally.

During the waking hours some protection against mosquitoes can be had by keeping fully clothed. Sport shirts and shorts are dangerous apparel in infectious regions. Since mosquitoes are attracted by dark clothing, some measure of relief can be found by wearing white suits and socks. Mosquito boots are well-known in English colonies but are scarcely heard of in the United States. These, with thin leather tops reaching to the knees and thin soles, are worn after dark to prevent mosquito bites.

Attacks from red bugs (also called harvest mites, or chiggers) and ticks can be prevented by dusting the body freely with flowers of sulfur. A small metal can with a shaker top makes the best container for the sulfur. If ticks become embedded in the skin, they can be loosened by holding a heated needle near them. In Latin American tropics the larvae of a warble fly (called *nuche* in Colombia and *torcelo* in Nicaragua) may sometimes cause serious trouble by developing in exposed parts of the arms or legs, sometimes even on the face or in the scalp. The infestation may be mistaken at first for a small boil, but the appearance of a delicate hairlike appendage, accompanied by an ooze, will indicate the true nature of the trouble. Some people calmly cut open the swelling and remove the parasite, but that procedure can lead to infection. The larvae can be killed by holding a bottle of chloroform or ether to the opening in the skin. Also they can be suffocated by covering the area with a piece of adhesive tape. After the worm dies, the contents of the wound can be gently pressed out like an ordinary boil, but care should be taken not to burst the maggot during the process, since some believe that absorption of the juices might cause serious shock.

Another common pest is the true chigger or chigoe (called *nigua* in Colombia, and *bicho do pé* in Brazil), which penetrates the skin usually near or under the toenails. A slight irritation, or itching, is caused. Examination will reveal a small whitish area with a black dot at the center, the black dot being the embedded insect. Removal is made with a flamed needle, care being taken not to break the egg sac attached to the insect.

Chiggers are said to be spread commonly by pigs, but they often occur on bathing beaches. One should never go barefooted, even indoors.

The larger animals usually will not be seen and ordinarily need not be feared unless they are wounded or protecting their young. Perhaps the most dangerous that one may encounter are wild pigs or javalís. They run in droves and will attack a man without hesitation. The best way to elude them is to climb a tree at once.

A ferocious fish occurs in some rivers of the Guianas and some tributaries of the Amazon. This is the famed piranha, the stories about which are not exaggerated. A man or animal with any sort of wound on the body going into the water where these fish abound is certain to be attacked instantly and severely mutilated if not devoured. Any thrashing about in the water will attract numbers of the piranha. Many people have lost fingers by merely reaching into the water, or even by letting a hand trail over the side of a canoe.

Fungus infections of the skin may be prevalent in hot, humid sections of the Tropics. There are various types of fungus diseases, and no one remedy is specific for all of them or for all people. The best all-around preventive probably is the regular use of a good antiseptic soap and keeping the skin as dry as possible.

These are the pests and dangers most commonly encountered. Others occur in isolated sections but need not be discussed here, since the traveler would be warned of them by the natives should he visit the particular areas.

A collector going into a foreign country should feel obliged to learn the language or dialect of the region, especially if he plans to gather first-hand information concerning native lore relating to natural-history objects. Of course, one may depend upon the services of an interpreter, but good ones are not always available. Furthermore, contact with natives through an interpreter even at best is impersonal and unsatisfactory. People of any country are more disposed to be friendly to a foreigner who attempts to speak their language.

Provincial people in any country are naturally curious about a foreigner, and so a newcomer should make it his business to be tactful and understanding. Really successful relationship with other peoples calls for more than just speaking their language, because mutual friendship, whether between individuals or nations, must be based on sincerity. The successful explorer will leave behind all prejudices and will accept the new people he encounters on a basis of equality.

PHOTOGRAPHY

Good habit photographs of plants in the open are possible, provided the background gives sufficient contrast. The sky, a body of water, or even the bare earth all make good backgrounds, but often plants are located in such a way that one cannot take advantage of any such desirable background. If a plant is sufficiently isolated from surrounding vegetation, good pictures can sometimes be made by careful focusing and by due consideration for light values. Or if a plant is small enough, an artificial background can be created by stretching a piece of gauze netting behind the plant. Sharp definition is difficult to secure when plants are growing thickly matted together, as is usually the case under tropical conditions. Sometimes the surrounding growth can be cut down to admit light and to give prominence to a particular plant.

An experienced collector will doubtless have his own preferences of cameras for field work. Obviously, though, a light compact camera is desirable if much distance is to be covered on foot. The writer has had best results when using cameras of the Rolleiflex type in combination with an exposure meter.

A major problem in low tropical countries is to keep clothing and equipment from mildewing. During the rainy season, shoes and books often develop a luxuriant crop of mold, even overnight. Anyone doing photographic work for a considerable time in the Tropics will come to look upon silica gel as indispensable for protecting film, negatives, or even the camera itself from deterioration. The camera lens can become permanently clouded by the action of molds that grow on the surface of the glass. This can be prevented by keeping the camera as dry as possible in the field and by storing it in a tight can with a quantity of silica gel when not in use. This is another reason for using a small camera.

If film cannot be supplied in tropical packing, in individual metal containers, perhaps some other type of moisture-proof covering can be found; failing that, it may be kept in a can of silica gel.

Experienced people agree that film deteriorates under hot, humid conditions, but there seems to be no agreement as to the rapidity of the deterioration. A safe rule is to expose the film as quickly as possible after it is opened, within 4 days at the maximum but preferably during the first day. If the loaded camera can be left in a silica-gel container, so much the better. When exposed film cannot be protected with silica gel or developed locally, it should be wrapped in waxed paper and shipped at once to a dry climate.

HOW TO ADDRESS SHIPMENTS FOR ENTRY INTO THE UNITED STATES

Any living-plant material coming into the United States is subjected to a strict examination and for this reason must be addressed as follows:

Plant Inspection House,
Division of Plant Exploration and Introduction,
United States Department of Agriculture,
Washington 25, D. C.
EE. UU.

LIVE PLANTS

Shipments not so directed are liable to interception at the port of entry and to delay for compliance with the plant-quarantine import regulations enforced by inspectors of the Bureau of Entomology and Plant Quarantine.

Other types of material, such as dry pressed specimens, analysis samples, and dead insects, might be sent also to the Inspection House to receive a routine fumigation. The package could be marked: "Natural-History Specimens," "Dried Plants," "No Commercial Value," or with some other suitable legend. The name of the collector, or shipper, must appear on, or at least inside, the package to prevent confusion with other shipments.

Living material cannot be delivered directly to private individuals without the formality of securing previously an import permit and a special shipping tag.

Shipments through the Plant Inspection House will be greatly expedited if a letter is sent by air mail giving instructions for disposal of the material after inspection and fumigation. The letter should describe

the shipment adequately, that is, state the number of packages, how packed or wrapped, and the probable date of arrival.

Shipments by boat, such as ocean express or freight, to any Government agency, should be consigned as follows: United States Dispatch Agent at New York, New Orleans, or San Francisco, depending upon the route. Here again, in a letter of explanation to the Dispatch Agent, it is necessary to give a description of the shipment and probable date of arrival as well as the name and address of the consignee.

Under normal conditions, special arrangements can be made with United States diplomatic or consular officers to transmit scientific material by diplomatic pouch to the Inspection House. This is particularly important when living-plant material is concerned.

When a shipment consists of more than one package, the separate items can be marked package 1, package 2, etc. All packages must be well wrapped, with an outer covering of muslin securely sewed on. Boxes must be strongly constructed. Extreme care should be taken with shipping directions and address tags, making certain that duplicate information is enclosed in the package. The outside address may be typed on linen tags, and these should either be sewed or nailed on, depending upon the type of container. The address, also, may be painted on wooden boxes, or written with an indelible pencil on cloth covers. Ink is not dependable unless it is waterproof. Legibility is, of course, essential.

GENERAL INFORMATION NEEDED FOR SPECIMENS

The need for making good specimens and for furnishing adequate information about the specimens becomes apparent if one realizes that his material may be added to the collections of a scientific institution and that as such it will be available for study by scientists in future generations. Omission of any one of the essential data detracts from the value of the specimens; if all data were missing, even perfectly prepared material would have little or no value for scientific purposes. Despite this fact, many collectors persist in writing skimpy notes. Most scientific institutions have great quantities of natural-history specimens which are almost worthless because of insufficient data.

Regardless of what is collected, whether it be a pressed specimen from a tree, an insect, a fungus, a plant product for chemical analysis, or material for planting, the essential and minimum data required are the same for all. (See specific remarks under the separate headings of Pressed-Plant Specimens, Plant Products for Analysis, Propagation Material, Diseased-Plant Specimens, and Insect-Pest Specimens.) The following five paragraphs indicate, in general, the kind of information needed:

1. *Name (or kind) of material.* Some sort of descriptive term should be used as: Cultivated cinchona; wild sunflower; drug plant for analysis; stem borer of flax; leaf blight of peach tree; etc. The native or local common name should be sought also.
2. *Where collected.* The locality should be cited definitely enough to be found on a standard map. Preferably, the place should be indicated in such a way as to permit another person to revisit the exact area even years later. In sparsely populated areas it may be necessary to cite longitude and latitude.
3. *Supplementary notes.* These cover facts about the specimen which are not obvious in the specimen itself. The notes should be as brief as possible yet adequate enough to give a clear word picture of the specimen in its natural state.

4. *Date of collection.* Some collectors, to save time and space, write 7/4/44 to indicate July 4, 1944, but Europeans and Latin Americans would interpret this symbol to mean the seventh day of the fourth month in the year 1944, or April 7, 1944. To avoid confusion it is best to use Roman numerals for the month, VII/4/44, or else to spell out the month as July 4, 1944.
5. *Name of collector and collector's number.* The collector's complete name should be clearly written. Each collector should make certain that his name always accompanies his specimens; otherwise there might be danger of confusing the specimens of different people when the material is received elsewhere for study.

Collector's numbers are essential and always should be used if any extensive series of specimens is to be accumulated. The number serves as a convenient symbol in referring specifically to a certain set of specimens of a given species, collected at the same time and place, and growing under the same conditions. It is used in correspondence, in lists of identifications, and also for citations in scientific publications. The collection numbers should start with 1 and continue consecutively in a single series throughout the years, regardless of how many countries or places may be visited. Some collectors are prone to begin a new series of numbers each year, or they may sometimes assign the same number to two different plants or to plants from widely separated localities, but such a procedure leads to endless confusion. It is essential to have a single series of numbers and to keep the system as simple as possible.

Of course, no hard and fast rule can be laid down to cover all situations, and each person will work out a scheme to fit his own needs. For instance, if one were collecting extensive series of material in unrelated groups such as plants and insects, it doubtless would be desirable to maintain separate lists for each group. In such a case the major group might be assigned straight serial numbers, and the groups of secondary importance or interest might be designated by combining letters with the separate series of numbers; that is, I-428 would indicate—Insect collection No. 428, or F-326 would indicate—Fungus collection No. 326.

If one were making primarily a large series of dried pressed specimens of a specialized crop like quinine and adding, only occasionally, an insect pest, diseased plant, or propagation material which related to the main series, then he might best assign the same collection number to all but still use the initial letter "A," "I," "F," or "P" to designate the supplementary items (see sample entries and explanations pp. 11-12).

HOW TO KEEP FIELD NOTES

The collector should have two types of notebooks in which to keep field data; one should be small enough to carry in the pocket for recording brief information at the time of collecting, the other, a larger, ledger type of book, to be kept at headquarters and used for making permanent records at the end of the day's work. It is most important that pertinent data be written down at the time of observation. Do not trust to memory weeks, days, or even hours later.

Some collectors prefer to carry with them printed forms, such as perforated leaflets bound into booklets (see fig. 1). By use of a carbon interleaf it is possible to have a copy of the field notes which can be detached and incorporated with the specimen. This method is apt to have several disadvantages. Most people do not write legibly at all times and this fact, coupled with field conditions unfavorable for writing, too often results unsatisfactorily. Then, too, the carbon copy may

become blurred, if not actually soiled, by contact with the specimen; also there is some danger that the copy may become separated from the specimen.

Field No.	Latin name
Local name	P. I. No.
Locality data	
.....	
Plant description	
.....	
.....	
Special notes	Wild?
.....	Cult?
Collector	Date
PLANT EXPLORATION AND INTRODUCTION, BUREAU OF PLANT INDUSTRY UNITED STATES DEPARTMENT OF AGRICULTURE <small>U. S. GOVERNMENT PRINTING OFFICE 8-3495</small>	

FIGURE 1.—Page from field notebook as used by the Division of Plant Exploration and Introduction, U. S. Department of Agriculture.

The disadvantage of the permanent notebook is that it might be lost; also, a typed list must be made when specimens are sent away for study. On the other hand, the notebook system is more convenient for reference and for making final labels.

Another favored method is the use of consecutively numbered tags, or small paper squares, which are attached to or placed with the specimens. Such a system might be too troublesome or time-consuming for extensive collections of pressed plants but might be suitable for insect specimens or plant-analysis material.

Some plant collectors prefer to enter at least some of the collection data on the margins of the newspaper folder in which the plant is collected, but this method can be unsatisfactory, because sometimes the margins are not wide enough for writing; also it is difficult to write on the folders when the press is full (see also Hints on Pressing, p. 20).

The method used by the author has given satisfactory results over a period of years. This consists simply in putting the specimens into the collecting case, one after the other in the same order in which they are collected during the day. Pages from a small pocket notebook, or uniform slips of paper, with brief penciled notes, are inserted to separate various groups of plants coming from different localities and environments. Additional slips are used for special notes about individual plants. Later, as the plants are being transferred into the press for drying, and numbers are being assigned to the collections, these brief notes are expanded and written in ink in the permanent notebook. If desired, the penciled notes may be left permanently with the specimens.

SAMPLE EXTRACTS FROM A PERMANENT FIELD NOTEBOOK

Space should be reserved at the front of the permanent notebook for explanations of symbols and abbreviations used in the notes. For example:

1. Abbreviations, or words in parentheses following the vernacular names of plants indicate the source of the name: (Br.)—Brazilian; (Chibcha)—Chibcha Indian; (Tupi)—Tupi Indian; (Guar.)—Guarani Indian; (Sp.)—Spanish.

2. To prevent confusion, the following four letters are placed before the collection number and appear on the tags of all supplementary material:

A—Analysis material collected.

F—Fungus, or diseased-plant specimen collected.

I—Insect specimen collected.

P—Propagation material prepared.

3. Abbreviations in text:

coll. —collection	km. —kilometer
cult. —cultivated	lvs. —leaves
flr. —flower	m. —meter
frt. —fruit	photo. —photograph taken
ft. —foot or feet	spec. —specimen
	etc.

(FIELD NOTEBOOK)

Chas. Birk Clarke

Beginning collections in Colombia, South America
Departamento de Cundinamarca. Year 1939.

4280–4283 10 km. W. of San Martín de la Cruz, on banks of Rio Suciatetomba. El. 1,000 meters. Black silty soil. July 7.

4280 *Sapium*

Sangre de drago (Sp.); *etawawa* (Chibcha).

Slender tree, 20 ft. high, forming thickets. Flower bright sulfur yellow, with pink stamens; fruit blackish when ripe, splitting to expose two bright-red seeds; leaves oily when crushed, with camphorlike odor. Natives use leaf decoction as cough cure.

Photo 18-3. A-(leaves).

4281

Orella de burra (Sp.); *tatawán* (Chibcha).

Medium tree, 30 ft., spreading top, growing in open places. Upper leaves with bright-red markings. Fruit black, with sticky, yellow pulp. Powdered root said to be used to kill head lice.

A-(roots). I-(leaf scale).

4282 Fern

In extensive clumps, overhanging water. Rhizome with pleasant odor.

4283 *Phyllanthus*

Muirú (Chibcha).

Slender shrub, 4 ft., with scanty foliage; flr. greenish. Slight, yellowish latex in stem. Juice used by local Indians to cure insect bites.

4284 Grass

San Martín, N. edge of town. Dept. Cundinamarca. El. 3,000 m. July 10. Forming thick turf under trees, heavily grazed by cattle. Red clay soil.

P-(roots, seed).

4285–4290 20 km. E. of San Martín, Dept. Cundinamarca. El. 4,000 m. July 15. Steep rocky slope. Gravelly loam soil.

4285 Cinchona

Quina (Sp.)

Shrub, 10 ft. high, globular shape. Uncommon here. No flr. or frt.

Photo 18-4 & 5. P-(seedlings from below shrub). A-(bark).

4286 Composite

Anis (Sp.)

Growing flat on ground in open places, very common. Some plants 2 ft. across.

Flr. yellow; crushed leaves smell strongly of anis. Used to flavor food and alcoholic drinks.

4287

Beginning Collections in Brazil, S. America
Estado do Pará. Year 19405001-5040 Fazenda Itataquibinha, on Rio Tapajós, 50 km. up river from junction with Rio Amazonas. Muddy silt soil, flooded *igapó*. El. 300 m. Nov. 3.

5001

Lengua de jacaré (Br.); *ininitá* (Tupi).

Aquatic, forming small floating islands. Flr. pale yellow, closing during day, sweet-scented. Seed gelatinous, eaten by fish.

5002 Swietenia

Cedro-y (Guar. & Br.).

Huge tree, diam. 15 ft., about 80 ft. high. In dense forest, branching only at top.

Fruits falling into water to disintegrate and liberate seed. Used as construction timbers, canoe paddles, and cabinet making.

Fruits separate. F-(leaf spot). P-(seed and 6 seedlings).

5003

This method saves a great deal of laborious repetition, especially when the locality names are exceedingly long, by including under group entries, i.e., 4280-4283, 4285-4290, and 5001-5040, all the data common to collections of the group.

The last line of entry 4280 indicates that a photograph (Roll No. 18, exposure 3) has been taken of the plant. A-(leaves) indicates that analysis material was collected. For entry 4285, two photographs (Roll No. 18, exposures 4 and 5) were made; propagation material consists of seedlings; analysis material was collected. Entry 5002 shows that the propagation material consists of seed and seedlings, and that F-(leaf spot) is represented by a collection of diseased leaves. "Fruits separate" means that the pods were too large to be pressed with the specimen and consequently are to be found separately in a bag or some other container. All supplementary material must be correctly numbered (p. 9) and securely tagged to show its relation to the corresponding pressed specimens. As an additional safeguard, the date could be written, also, on the tags.

PRESSED-PLANT SPECIMENS

KIND OF DATA NEEDED

Remarks under General Information Needed for Specimens (p. 8), as well as the sample extracts from field notebooks (p. 11), indicate the ordinary kind of information desired. As mentioned previously, the notes should present a brief but clear word picture of the specimen

in its natural state—facts which will be of value later when the mounted specimen is examined by botanists or others who need definite data for their studies. Obviously, there is no need to describe any features, such as the shape and size of the leaf, or whether or not the plant is hairy, which can be seen by looking at the dried specimen itself. Most of the important information can be recorded in comparatively few words. For large plants (trees, shrubs, vines) mention the size and the characteristic shape (habit). The natural growing conditions (habitat) are important; i.e., aquatic, swamp, dense forest, open places, roadside, mountain slope, river bank, weed in field, cultivated, etc. The color of the flower, of the ripe fruit, and of the fruit pulp and the odor of flower, fruit, leaves, bark, wood, or roots, if noticeable, should be noted, because such characters are liable to disappear upon drying, especially the color of the flower and fruit. In botany, the term "fruit" applies to any structure which bears the seed of the plant, whether it be a mango, bean, or a tomato.

Sometimes words can be saved by making photographs or outline sketches to show the shape of the plant, of the flower, or the fruit (figs. 5, 22, 25-28). The type of soil (rocky, sandy, clay, silt), briefly described—acid or alkaline, wet or dry, well-drained—is often important, especially if the plant is to be grown later in a new place. Small field kits are available for determining the pH values of soil.

Native uses or local importance of plants should be recorded; even brief notes, such as "grazed by stock," "roots eaten raw by natives," "fruits eaten by birds," "important lumber tree locally," "controlling erosion in sandy places," etc., add value to the specimens. Strangely enough, most plant collectors never bother to gather such information, perhaps for lack of interest or time, or because they have not learned the local language or dialect. Any collector in a distant region should feel duty-bound to secure all possible data on the economic uses of plants, particularly when he is in contact with Indian tribes or other native peoples. When this continent was discovered, the white man adopted only the more obvious plants, such as the potato, corn, tobacco, and quinine, but attached little importance to the thousands of other plants utilized by the Indians. As Indian tribes die out, or become civilized, this native lore may be lost forever. Among many tribes today, only the oldest members can give information about plants. The person who makes a serious attempt to gather such data will render great service to science. Interesting specimens and data of drug and food plants can be found in market places. Careful search often yields flowers or fruits in the material offered for sale (figs. 13, 21).

The collector should, however, exercise discrimination when securing information from natives, especially primitive peoples. Do not believe everything you are told. Verify the statements by asking different individuals. A guide, or an Indian, may assign imaginary values to a plant merely to impress the "foreigner," particularly if the informer expects to receive pay for his plant knowledge. Information may be intentionally misleading, too, when a medicine man is protecting his "trade secrets," or perhaps for some other reason. It is here that the collector's ability to speak the dialect or language of the country will be most advantageous; likewise his talent in establishing friendly relations with natives.

EQUIPMENT FOR PLANT COLLECTING

For obvious reasons, the amount of equipment to be carried about should be kept to a minimum. This is especially true when traveling in regions where transportation facilities are unfavorable, or when long distances are to be covered on foot. Minimum requirements for the field are: Collecting case (portfolio) (fig. 3); folded-newspaper sheets; knapsack; small pickax (entrenching tool) (fig. 2, *A*); pruning shears (snap-cut type) (fig. 2, *B*); pocket lens (6 to 7 x magnification); pocket compass; stout pocketknife (Boy Scout type); paper or cloth bags for seed, roots, or analysis material; stout eyelet tags for marking large bulky fruits and bagged material; strong twine. A large, flat bag with handles will be convenient for carrying bulky fruits or propagation material. A waterproof knapsack is extremely useful for long trips by foot.

FIGURE 2.—Collecting equipment. *A*, Small pickax (entrenching tool); *B*, snap-cut pruning shears.

A piece of oilcloth may be carried to protect the collecting case from rain. Also, longer pieces of oilcloth can be used for collecting plants if so desired. To keep the individual collections separated by this method, the oilcloth is used as a roll—the first collection is placed at one edge and the roll given a slight turn; then the second collection, another slight turn; and so on until full. The ends of the roll are folded over toward the middle and tied with a string to keep the plants from drying out. By this method the full rolls can be cached and picked up on the return trip to camp.

Collecting cases (portfolios) vary in design and construction according to the purpose and ideas of the people using them. For small-scale, or incidental, work a special collecting can (vasculum) is most useful, especially for bringing in living material for transplanting. In an emer-

gency, a pulp-paper magazine carried under the arm can serve to press a few small specimens. When no collecting case is at hand and the specimens must be carried a considerable distance before being pressed, the plants can be kept from wilting by wrapping them in waterproof paper, wet newspapers, or wet cloth.

FIGURE 3.—Collecting case (portfolio).

For large-scale operations the collecting case should be of simple design and sturdy construction. For reasons to be explained presently, it should measure about 12 by 17 inches. The one illustrated (fig. 3) is made of slightly flexible, wooden slats, fastened together with brass nails. At the bottom, the pieces of punched leather fitted with small tongue buckles permit extension of the case to accommodate the contents. A heavier strap and a tongue buckle can be used at the top for closing the case, but to facilitate the constant opening and closing it is better to insert a small metal knob at the top of the opposite frame as a substitute for the buckle. Applying pressure on the filled case will allow a hole in the strap to engage the knob. The case is carried easily by means of the hand strap at the top. For covering long distances afoot, and when the press is full, the case can be carried more conveniently on the back by slipping the pickax through the hand strap, with the handle of the pickax passing over the shoulder to the front to be partly supported with the hand.

A simpler, but less serviceable, case can be made from two pieces of plywood, or heavy cardboard, with holes at the bottom through which

stout cords are passed. The cords are tied at the top to close the case.

The collecting case is filled with folded-newspaper sheets, opening on the long, *not* the short, side (see Equipment for Plant Pressing, p. 20). To keep the individual sheets from slipping about during the constant opening and closing of the portfolio, it sometimes helps to make up "booklets" of the sheets; that is, to insert about 10 of the sheets inside another sheet.

Any sort of sturdy pruning shears will serve, but experience has shown that the type known to the trade as "snap-cut" (fig. 2, *B*) is more satisfactory than some others. The snap-cut type is usually made of lightweight metal; the lower blade acts as an anvil, with the upper blade striking along a groove in the center of the anvil; also, the points of the blades are rounded and fit better into the hip pocket.

The pickax best suited for the purpose is the small entrenching tool as issued by the Army, but these are now difficult to obtain, even in second-hand shops. However, some biological-supply houses offer a special plant-collecting pickax. A geologist's pick hammer can be used but is not so serviceable. The entrenching tool has a blade for cutting through roots or digging in hard soil, whereas its pointed end is ideal for work in rocky ground.

In tropical vegetation a machete is almost essential for cutting trails, hacking thick branches, opening hard fruits, etc.

COLLECTING HINTS

Enough material should be gathered to make at least two complete specimens—one to keep and one to send away for identification. However, additional material is always desirable, if time and conditions permit. Duplicate specimens always enhance the value of collections, because the extra material can be deposited in scattered institutions and thus become available for study by scientists in various parts of the world. Ten or more duplicates should be made of important plants.

As the plants are collected, they should be inserted in the portfolio in the same order as that in which they are collected throughout the day, each collection occupying a separate page. Maintaining this order will save time later during pressing operations, numbering of the specimens, and in writing the permanent notes (see p. 21).

It is better to make 10 good specimens than 100 poor ones. Remember that the specimen must fit within a frame measuring $11\frac{1}{2}$ by $16\frac{1}{2}$ inches, which is the size of the standard sheet used in botanical institutions of the United States for making permanent mounts of dried plants (see figs. 5-24). Select material with this idea in mind. Careful search usually yields sprays that will lie flat in the press. The flatter the specimen the better; any undue bulge from matted roots, crooked or thick stems, or large fruits will result in shriveled leaves and unsightly specimens. Furthermore, such material is difficult to mount later and also takes up too much room in the filing cases. Try to collect from normal-looking plants, not from sickly or weak plants, or those injured by hail, frost, or fire, or damaged by insects, especially if the leaves are mutilated. In the Tropics, leaf-cutting ants sometimes are so active that considerable search may be required to find a specimen with undamaged leaves. In some plants, especially trees, the young and old leaves may differ in appearance, and the collector must attempt to include both kinds in his specimens. When smaller plants display a considerable

range in size, it is best to collect average-sized plants and to record the total range of size in the notes. If all the plants are quite small, that is, ranging from 1 to 6 inches high, the collector can include plants of all the sizes in his specimens (also see fig. 16).

Care should be taken to keep the specimens clean; usually collecting should not be done during, or immediately after, a rain, because the plants are apt to become stained with mud, which is difficult to remove once the plants have dried. When possible, the entire plant is collected, including the roots (figs. 12, 14). The roots must be dug carefully, because often they have special characters which are lost or damaged if the plant is pulled out of the ground. Soil and gravel must be removed by shaking or knocking against a rock or a tree trunk. Sometimes it becomes necessary to resort to washing, but some types of plants growing in wet clays or having densely matted roots cannot be cleansed of dirt even by washing. In collecting such plants as grasses, the clumps and the tangled roots will have to be cut or pried apart. A few stubborn examples will need to wait until the drying is completed, when the dirt can easily be broken loose. A convenient tool can be made from a small varnish brush by inserting a sharp spike in the end of the handle. The spike is used to gouge out dirt and gravel from the roots, and the brush, to clean dust and dirt from the leaves. Many collectors are inclined to be too rushed to bother about the sand and gravel in their specimens, but invariably such debris damages the dry specimens. Furthermore, there is the added weight which must be carried or shipped.

In identifying plants, botanists depend chiefly upon the structure of the flower or the fruit. Sometimes both are needed. Consequently, a sterile specimen (one without either flowers or fruits) is rarely worth the trouble of collecting. The only exception would be in the case of some plant of unusual importance when only a sterile, or poor, specimen was available (see fig. 13). Even so, the collector should make every effort later on to secure adequate specimens for identification. The ideal specimen bears both flowers and mature fruits, or seed, on the same branch, but these do not always occur together, or at the same time of year. In woody plants the flowers and fruits may be borne on different branches and may then be collected together as a single specimen, but this must not be done unless both come from the same plant. It is never safe to mix collections from different trees or shrubs under one collection number, unless the fact is clearly stated in the notes. It should not be done in any case, unless the collector has good reason for believing that the different plants belong to the same species.

When old fruits are collected from the ground where they have fallen from the tree, the fact should be stated in the notes. Old fruits can have considerable value, but one must be fairly certain that they belong to the tree in question. This can be judged by conditions and by the location of the tree. In some groups of plants (especially in the legume or bean family) the fruits are usually essential for accurate determination of the species.

In dense jungle growths the tops of the trees can rarely be seen, and for this reason the collecting of tree material is somewhat difficult. Experienced collectors in such regions watch the forest floor for fallen flowers or fruits. Sometimes the buzzing of bees or the odor from the flowers will serve as a clue that a certain tree is in bloom. Dr. Adolfo Ducke, the well-known authority on Amazon trees, carries a pair of field glasses as an aid in spotting flowers and fruits in exceedingly tall or dis-

tant trees. Tree species are probably the least known in tropical floras, owing not only to the great difficulty in locating the flowers but also to the trouble of collecting the material afterward. Hardness of the wood and girth of the trunk often make tree felling an arduous task. Furthermore, jungle vines or surrounding vegetation sometimes keep the tree from falling to the ground and make further chopping necessary. A more practical method is to rely upon the help of a native who is experienced in tree climbing. The above-mentioned botanist formerly employed a shotgun to shoot the specimens down.

PALMS

Palms are highly important economically, but as a group they are imperfectly known botanically. This is partly because satisfactory pressed specimens are difficult, if not impossible, to make. Consequently, good representative material of palms in collections is scanty indeed. The leaves and the flowering and fruiting parts of most palms are so huge that the usual kinds of botanical specimens are entirely inadequate. Nevertheless, an experienced collector with time and patience undoubtedly could make a valuable series of records. The problem requires a judicious combination of field notes, photographs, and carefully selected portions of the plant to serve as pressed specimens (figs. 22-28).

The field notes need to be more complete than usual and should include accurate measurements and descriptions of all the various critical parts: Height of the plant up to the leaf crown; diameter of the trunk; length of the leafstalk; dimensions of the leaf; form of leaf, whether feather- or fan-shaped; number and arrangement of the flowering and fruiting clusters; of the envelopes or spathes (figs. 24, 28); odor and color of flower; color of fruit; arrangement of leaf scars on trunk; arrangement of spines, if any; etc. It is to be noted that in some kinds of palms the flowers and fruits occur at the same time and in the same cluster.

A single plant might require six or more photographs (figs. 25-28), including a general view of the entire plant to show its shape, one or two close-up views of the trunk, one of an entire leaf, and one each of the flowering and fruiting clusters.

The portions selected for pressed specimens conceivably would include the following: A section of the leaf, as large as possible, in order to show attachment of the leaf segments to the midrib (fig. 22); terminal, middle, and basal portions of the leaf; lower portion of the leafstalk to show manner of attachment to trunk, including the leaf-base sheath (fig. 28); section of trunk to show spines, if any; portions of both the flowering and the fruiting cluster; and the envelopes (spathes). Note that the parts selected for pressing from a fan-shaped leaf should include the basal portion to show manner of attachment to the leafstalk, which is quite important. The remaining pieces should be cut to give the best representation of the whole leaf. An extra quantity of loose flowers and fruits is always desirable. The fruits should be complete, including all the outer shells or pulp.

BAMBOOS

Bamboos also present difficulties in the preparation of adequate specimens. Usually the collector does not succeed in gathering the portions needed or a sufficient quantity of material, but patience and

care will yield specimens suitable for preservation. Flowering specimens always should be obtained if available, but fortunately they are not entirely necessary for the identification of bamboos, provided the samples from other parts represent the plant adequately. It is very important that the series be as complete as possible, and it is to be noted that as many as 10 or more sheets might be required to include all the samples from a single bamboo.

A complete series (see figs. 18-20) would include the following: (A) Section (internode) of mature stem taken to include the 4th and 5th joints (nodes) above the ground; (B) leafy twigs; (C) portion from about the middle of the stem, with branches (branch complement) attached, as well as several detached branches; (D) several of the sheaths, which enclose the stem and young shoots, to show range in size; (E) piece of stem to show the branch bud, which occurs just above the joint; (F) lower piece of a stem attached to the underground portion (rhizome); and (G) young seedlings if available.

In gathering samples for a bamboo specimen, the collector must make certain that all come from one plant or at least from one clump. Be careful not to collect, under one number, samples from different bamboos growing so close together in a clump as to appear to be a single plant. Any portions proving too bulky to be pressed flat can be carefully tagged and then dried thoroughly before shipping or storing.

Sketches and photographs assist greatly in showing the relationship of the various parts collected. The notes should include: Habit of the clump and the stem; maximum height of stem and maximum diameter at base; length and diameter of 5th internode; length and serial number above ground of the longest internode. Actual and accurate measurements are preferable, but if they are merely estimated the fact should be clearly indicated in the notes.

EQUIPMENT FOR PLANT PRESSING

Slat frames (or press ends) identical in construction with the frames used in the collecting portfolio.

Ventilators, double-faced cardboard, with corrugations extending the short length, that is, crosswise and not lengthwise.

Blotters (or botanical driers).

Folded-newspaper sheets.

Lengths of cotton sash cord, about 2 yards long, tied to form a loop at one end (see figs. 4, 29).

Smaller articles will be represented by pen, permanent ink, lead pencil, red-wax pencil for writing numbers on sheets, dissecting knife, dissecting scissors, 8-inch shears for trimming paper, and safety-razor blades.

For convenience, the slat frames, ventilators, blotters, and newspaper folders should all measure $11\frac{1}{2}$ by $16\frac{1}{2}$ inches, but strangely enough this uniformity of size in materials is not so easily accomplished as might be assumed, because the materials stocked by various commercial houses vary considerably, not only in dimensions, but also in quality. The objective in plant collecting is to produce a dried pressed specimen to be mounted on a standard sheet that measures $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. To accomplish this objective, the use of pressing materials which exceed that size represents waste, not only in the original purchase price, but also in transportation charges to and from the field.

Commercial slat frames are usually unsatisfactory because of flimsy wood, poor construction, and excessive price. They can be made easily and cheaply from ash or oak strips, but any similar flexible wood will serve just as well. The slats should be $\frac{1}{4}$ inch thick and about 1 inch wide. Small brass screws or small brass nails, properly clinched, are best for fastening the slats together, but ordinary screws or nails will serve just as well.

The ordinary botanical blotters are dark gray in color and of variable quality and thickness. A medium weight is best for all purposes, but regular desk blotters can be used, despite their comparative thinness.

Ventilators are nothing more than pieces of ordinary, double-faced, corrugated cardboard. In fact, cardboard cartons often can be cut down to make satisfactory plant-drying material. Some commercial ventilators are made of soft paper and therefore go to pieces within a short time.

Folders usually are made from old newspapers, but most newspapers are too large and need to be cut down to the desired size. The trimming is done so that the folders open on the long side, *not* the short side (see fig. 4). Newsprint sheets, measuring 23 by 33 inches, can be purchased. These need to be folded.

The lengths of sash cord are used to maintain sufficient pressure to keep the plants completely flat during the drying process. To accomplish this, a piece of rope is fastened around the filled press about 5 inches from either end. The loose end of the cord passes through the loop, is pulled tight, and is then tied with a slipknot (figs. 4, 29). Some collectors prefer web straps for this purpose, but these are more expensive than the sash cord. Furthermore, they are not available everywhere and hence cannot be easily replaced when worn out, lost, or stolen. On the other hand, the sash cord can be purchased nearly everywhere and is not so apt to be stolen.

HINTS ON PRESSING

For best results, the process of pressing and drying must begin soon after the plants are collected. Four to 6 hours will allow a safe margin. At least a few hours should elapse in order to let the plants wilt slightly, because a limp plant can be arranged more satisfactorily for pressing. Crumpled leaves can be smoothed out and some can be turned so that both leaf surfaces will be visible in the dry specimen (figs. 9, 11). Sometimes as much as 24 hours can elapse, but much depends upon the kind of plant and the climate. Some plants will collapse and spoil within a few hours, especially those with delicate flowers and leaves. But grasses and coarse-leaved plants may be kept several days. Hot, humid weather will cause specimens to sweat and disintegrate more rapidly than cold, moist conditions.

Much time can be saved by proper arrangement of materials. If no table is available, some sort of bench can usually be improvised from boards and boxes. The collecting case is placed at the right so that the newspaper folders open to the right. The press lies directly in front of the operator, with the folders opening to the left. Separate piles of folders, ventilators, and blotters are arranged to the left and to the front within easy reaching distance. The permanent notebook, together with pen, pencils, and other small objects, might be placed on a small table or stand at the right. A small flat cardboard box makes a convenient receptacle for keeping smaller working tools together in one place.

The first plants to go into the press will be the first collected during the day, thus following the same consecutive order in which they were put into the collecting case. Maintaining this consecutive order, both in collecting and pressing, prevents confusion and saves time, especially when entering the field notes in the permanent record book, and when assigning collection numbers to the specimens. The collection number is written, preferably with a black- or red-wax pencil, in the lower left-hand corner outside the newspaper folder. Duplicate sheets, or supplementary material, of the same plant are marked in like manner. Placing the number always in the lower left corner aids greatly when the specimens are sorted numerically after drying is completed.

FIGURE 4.—Plant press, opened to show order of contents. From left to right are seen: Slat frame; corrugated ventilator; blotter; opened drying sheet; plant specimen; blotter; ventilator.

The order of various items in the press (fig. 4) are as follows: Ventilator; blotter; newspaper folder, opening to the left so as not to cover the plants in the collecting case; the plant specimen; blotter; ventilator; blotter; another folder with plant; and so on until the pile is built up to a convenient height of 2 or 3 feet. Piles higher than that may prove cumbersome to handle. As the pile grows, the sides should be patted occasionally to even up the ventilators and blotters. Neatness is essential. Tag ends of plants or folders should not stick out of the press, especially if the drying is to be done over a fire.

A usual practice is to keep plants in the folder in which they were originally collected throughout the drying operation and on indefinitely,

but the method is impractical, especially in the Tropics, because folders used for collecting become wet, wrinkled, or even badly soiled. For this reason, plants should be pressed in fresh folders, keeping those in the collecting case for repeated field use.

The arrangement of the specimens on the newspaper sheet for pressing requires a degree of care or even imagination. One needs to keep in mind the final appearance of the specimen when mounted within the frame ($11\frac{1}{2}$ by $16\frac{1}{2}$ inches) of the mounting sheet (see figs. 5-24). The mounted plant in figure 15 shows that a free space must be available in the lower right corner for attaching the permanent label. The sheet should be filled as completely as possible without overcrowding. Pressing will not be satisfactory if thicker stems or bulky portions occur in the center of the press; therefore the lumpy parts should be arranged to lie along the margins or in the corners if possible (see figs. 13, 14, 19). Also it is best to alternate them so they will come in different places and thus keep the press level. Low places can be sought out by pressing down with the hand. At times, paper can be wadded around a thick fruit or stem to keep the nearby leaves flattened during the drying period. Never press plants with matted roots filled with gravel or soil (see p. 17). Sprays of woody plants should be about 10 inches long. Small plants should be sufficient in quantity to fill the sheet (fig. 12), but they should not overlap while drying, because they are apt to stick together and thus be difficult to separate without breakage. Broad, or long, leaves can be partly folded over, or bent at an angle (figs. 6, 10, 23).

If a plant is too long to fit on the sheet, the stem can be bent sharply at some convenient place to make a V. Slender plants up to 3 feet high, if not too leafy or branched, can be made to fit within the size limit by bending the stem sharply to form a narrow N, or even a W-shape (see figs. 7, 13, 15-17). When such plants are too leafy or branched to conform to this treatment, it is sometimes desirable to divide the plant into sections, pressing the parts separately. For instance, arrange the roots and basal leaves in one part, the central stem in another, and the terminal flowering section in a third. In these cases, it is necessary to mark the various sections by writing "Sheet 1," "Sheet 2," or "Sheet 3" after the collection number (figs. 5-8, 18-20, 22-24). Here again an outline sketch or a photograph might be valuable to indicate the relationship of the various parts.

Densely clustered twigs, leaves, and flower or fruit clusters should be pruned down so that all parts can be seen clearly and so that the specimen will not be too thick (figs. 7, 8). Thick specimens are difficult to dry and also to mount. Careful selection at the time of collecting should yield specimens that will lie flat on the sheet, as well as display an adequate quantity of flowers or fruits. Sometimes woody stems and roots have to be split, pared down, or pruned to make them lie flat (figs. 13, 14, 19). Enlarged knots or nodes can be pared off. So far as possible, the excess parts should be pruned from the back (not the front) of the specimen.

Rigid or thorny plants can be flattened before drying by crushing them between two boards. Some stiff plants, especially grasses, give considerable trouble in drying because the stems will not remain in place after bending. This difficulty can be overcome by inserting the bent stems into slit paper rectangles (fig. 17). The rectangles can be cut in various sizes from heavy paper or thin cardboard and kept on hand until needed.

FIGURE 5

FIGURE 5.—Handling bulky material by making two sheets; plant with large leaves. Sheet 1 includes the dried flower stalk, together with a drawing (see fig. 6).

FIGURE 6

FIGURE 6.—Sheet 2 of the specimen shown in figure 5. The left half of the leaf has been cut away and the remainder folded to expose parts of both upper and lower leaf surfaces; also the terminal and basal portions can be seen.

FIGURE 7

FIGURE 7.—Handling bulky material by making two sheets for plant with large terminal fruiting cluster. Sheet 1 includes a portion of the stem with leaves attached (see fig. 8).

FIGURE 8

FIGURE 8.—Sheet 2 of the specimen shown in figure 7. A portion of the fruiting cluster, cut to indicate method of branching. Note the stub of a branch at base of stem.

FIGURE 9

FIGURE 9.—A plant collected in flower (see fig. 10). Note some leaves turned to display lower surface.

FIGURE 10

FIGURE 10.—The same species shown in figure 9 is collected later, from a different locality.

FIGURE 11

FIGURE 11.—Example of collecting two sprays from same plant; one with two buds and a flower, the other with a flower and two mature fruits.

FIGURE 12

FIGURE 12.—Small plants collected in quantity to fill the sheet adequately

FIGURE 13

FIGURE 13.—Example of using the only available plant to make a rather poor specimen to accompany Indian medicinal data. The large plant was split lengthwise and then bent into an M-shape to fit on the sheet. Note that the bulky portion lies along the right margin.

FIGURE 14

FIGURE 14.—Two entire plants adequately fill the space of the sheet. The thick, woody roots, sliced and pared down, lie in the upper right corner.

FIGURE 15

FIGURE 15.—A long fern frond bent into a V-shape to fit sheet. Note that specimen occupies the entire space, leaving room at the lower right corner for the label.

FIGURE 16

FIGURE 16.—Long slender plant bent into an N-shape to fit within space of sheet. Note smaller plant included to indicate range in size.

FIGURE 17

FIGURE 17.—Tall grass bent into M-shape and held in position by means of slit paper rectangles while drying.

FIGURE 18

FIGURE 18.—Handling bulky material of a bamboo by making several sheets. First sheet represents the leafy portion (see figs. 19 and 20).

FIGURE 19

FIGURE 19.—Second sheet of bamboo specimen in figure 18. Showing from left to right: Portion of stem (internode) comprising two joints (nodes) and attached branches (branch complement); smaller stem, split lengthwise to display interior; terminal portion of young shoot still enclosed in sheaths. (node); two branches (branch complements); terminal portion of young shoot still enclosed in sheaths.

FIGURE 20

FIGURE 20.—Third sheet of bamboo specimen in figure 18, showing from left to right: Two pieces of a shoot still enclosed in sheaths, and four sheaths opened and pressed flat to display terminal structure and range of size.

FIGURE 21

FIGURE 21.—Specimen from herb market in South America, to accompany information served from natives. Although poor, the specimen served to identify the plant correctly.

FIGURE 22

FIGURE 22.—Handling bulky material of a palm by making several sheets. Sheet 1 represents a portion from the middle of a leaf, and a piece of the lower leafstalk with spines. In upper left corner is a photograph of the entire plant (see figs. 23 and 24).

FIGURE 25

FIGURE 25.—Example of four photographs of a palm, to accompany notes and pressed specimens (see figs. 26-28). Habit view of entire plant, with man below to indicate size.

FIGURE 26

FIGURE 26.—Close-up of palm in figure 25 to show details of the envelopes (spathes) surrounding the fruit cluster, and attachment of the fruit-cluster stems to main trunk.

FIGURE 27

FIGURE 27.—A single leaf from palm in figure 25 to show size, shape, and structure.

FIGURE 28

FIGURE 28.—Showing portions collected from palm in figure 25, to be kept for the pressed specimen. From left to right are seen: An entire fruit cluster; an envelope (spathe); a flowering cluster; another envelope; leaf-base sheath which attaches the leafstalk to the main trunk.

Large fleshy fruits sometimes can be sectioned either crosswise or lengthwise, both if possible, and the sections then pressed and dried. In such cases, a sketch or photograph of the fresh fruit is desirable. Large woody fruits often can be divided lengthwise with a hacksaw to leave half attached to the stem. If too large they had better be cut off and kept separately.

Fleshy plants are sometimes difficult to dry, but dipping them momentarily into boiling water will overcome the problem. Small cacti may be split and the juicy interior removed. Larger cacti should be photographed, or sketched, and only sections or segments pressed.

Delicate flowers like morning-glories, orchids, violets, or iris can be prevented from shriveling and collapsing during the drying by placing pieces of cellophane over and under the flowers. Cellophane is useful also to prevent juicy fruits or stems from sticking to the newspaper.

Loose flowers or fruits can be added to the sheets as extra material for future dissection and study, particularly if these parts are scanty on the specimen. Such loose pieces should be enclosed in a small envelope or piece of paper, properly numbered.

Badly wilted plants usually can be revived by immersing them for a few hours in cool water. Material that has dried up entirely sometimes can be salvaged to make presentable specimens by soaking in warm water. Afterward the excess water is drained off and the plants pressed as usual.

DRYING METHODS

Drying may be accomplished either by sun or by artificial heat. Sun-drying is most common, but, during inclement weather and in humid climates, artificial heat must be used. Artificial heat, when properly employed, is to be recommended as a uniformly dependable means for making perfect herbarium specimens under all conditions of climate or weather. Rapid drying is essential in producing good specimens with well-preserved colors. Fading occurs in improper and in slow drying, leaving the specimens unattractive in appearance and uniformly dull brown in color.

Artificial heat can be supplied in a number of ways. One highly successful method for the field consists in suspending a filled press above a small lamp-stove, with a canvas skirt wrapped around the press and extending to the floor to conserve and direct the heat up through the corrugations of the ventilators. These lamp-stoves burn kerosene and have a 2-inch wick; some types have two wicks. With ordinary care, there is no fire risk, but the wicks must be kept trimmed with scissors to prevent smoking, and the canvas must not touch the stove. Apparently these lamp-stoves are now difficult to find in the United States, but formerly they were available in the larger cities of Latin America. Ordinarily, kerosene barn lanterns should serve in place of the lamp-stoves, but under tropical conditions two lanterns under each press might be necessary to produce sufficient heat.

Portable, gasoline pressure stoves can be used, but there is danger, not only of developing too much heat and setting fire to the press, but also of generating gas fumes, which lead to explosions, especially if the stoves are confined in a room with little or no ventilation. Furthermore, constant vigilance is necessary to maintain the pressure in the reservoir.

When forced to improvise a method for drying plants, the collector, depending upon circumstances, can utilize ordinary cooking stoves, baker's ovens, boilers or engines on ships, charcoal braziers, or even the glowing coals of a campfire.

Whatever the source of artificial heat, the collector must be extremely careful to keep the heat from being too intense. If the heat cannot be supported by the palm of the hand, it is too hot for the plants and will cook rather than dry them. Excessive heat also makes the dried specimens too brittle.

FIGURE 29.—Drying box, about 4 feet long, designed to hold two full, or several small, presses. Note small press in position; also type of slipknot in rope. The electric-light bulbs are about 8 inches below the press.

Where electricity is available, a convenient drying box can be made. The construction is simple, being merely the fitting of a wooden (or metal) box frame, without top or bottom covering, with ordinary 100-watt electric-light bulbs placed at the bottom. The plant presses fit inside the box, resting on crossbars, about 8 inches above the electric-

light bulbs (fig. 29). The box should rest on feet to give a space of an inch or so at the bottom to allow circulation of air. By extending the length of the box, any number of presses may be accommodated.

When using the sun as the drying agent, or when all the space over the stoves is occupied, the blotters must be changed frequently, at least twice the first day, otherwise the plants will discolor badly, or even mildew and disintegrate, in which case the specimens are practically worthless. The blotters have to be dried out by standing them up against a wall, or by spreading them out on the floor or out-of-doors. This method is slow and scarcely practicable, except in dry climates with an abundance of hot sunshine, or when only a few plants are being handled.

Actually the use of blotters retards the speed of drying, because the heat coming through the corrugations of the cardboards has to penetrate the blotters before reaching the plants. Consequently, the drying process could be speeded up by leaving the blotters out of the press and using only the cardboard ventilators between the plants. The method has been used successfully in dry climates for all types of plants. It will serve, also, even in wet climates, for such plants as grasses and sedges, which are not too juicy, provided one has a good quality of smooth-faced cardboards and a dependable source of artificial heat.

An innovation suitable for tropical climates consists in using corrugated aluminum sheets as substitutes for the corrugated-cardboard ventilators. Aluminum conducts heat much more efficiently than cardboard, and consequently the plants dry quite rapidly. The aluminum sheets are about ten times more expensive than the cardboard but have the advantage of lasting indefinitely and furthermore of requiring less space when packed. The sheets measure $11\frac{1}{2}$ by 16 inches, with rounded corrugations $\frac{1}{8}$ inch deep and $\frac{1}{2}$ inch from crest to crest, the corrugations running crosswise, not lengthwise. The metal should be hard aluminum 0.008 inch thick. A special die is required to make the corrugations.

For drying only a few specimens, when none of the regular equipment is available, various methods can be improvised. The specimens might be placed between pieces of corrugated cardboard, firmly tied with string, and hung over a stove or other source of heat. Layers of folded paper are sometimes used as driers, but usually this method is unsatisfactory and results in ruined or mildewed specimens. Small specimens can be prepared by pressing them in magazines having rough, pulp-paper pages. But, even so, the specimens must be watched and changed to new pages to keep them from spoiling.

Whatever the system used for drying, one needs to have some means of knowing when the process is completed. This stage of dryness is best learned by experience. Most plants when dry, however, will be perfectly rigid when lifted off the sheet. Leaves should break with a snap when bent.

Fleshy leaves, such as those of orchids, and some types of roots, stems, or fruits often resist drying. If they dent easily when tested with a fingernail, they need further drying. The process can be hastened by making several crosswise slits in larger objects with a knife and by merely puncturing smaller ones with a needle or knife point.

Grasses and delicate thin-leaved plants should dry completely in less than 8 hours, and the great majority of plants within 24 hours if the heat is constant, day and night. For this reason the press should be examined daily, and those specimens that have dried sufficiently should

be removed. Some fleshy plants, like cacti or pineapples, may require as much as 2 weeks. When artificial heat is used, perhaps the examination should be made twice a day to guard against overdrying.

Good specimens should be entirely flat when dry; for that reason, the ropes on the presses must be tightened from time to time in order to maintain a constant pressure on the plants. With artificial heat, the ropes should be tightened at the end of 3 or 4 hours and at regular intervals thereafter. Plants dried under insufficient pressure will produce unsightly, practically worthless specimens, because the leaves and flowers will become shriveled and the stems distorted. Such material, also, is apt to shatter in shipment and, furthermore, causes great trouble in the final mounting.

For various reasons, it is important that the plants remain in the paper folders in which they were dried. The folders of dried plants can be kept in a convenient place until the entire lot has been completed. The piles should be weighted down or tied with a string as a precaution against accidents. A sudden gust of wind can ruin the labor of many days. Dried specimens should be protected overnight against the ravages of ants, cockroaches, mice, and other pests. Later the collections are sorted numerically and stored away for final disposition. To expedite handling and to avoid confusion, all duplicate sheets of a collection number should be kept together. This is best done by using one sheet as a cover with the extra ones inserted so that all can be handled as a single unit. Constant care is needed to prevent the contents of the sheets from sliding out, but usually the plant will have adhered slightly to the sheet during the drying process, and ordinary handling will not dislocate the specimens. Some collectors feel that extra precaution must be taken and often attempt in various ways to attach the plants to the sheet. The use of adhesive tapes, or even glued-paper strips, is to be discouraged as a waste of time, both for the collector and for the person who must finally unstick the specimen. Adhesive tapes often leave a gummy deposit on specimens, which is difficult to remove.

In very humid climates, dried specimens will need protection against absorbing of moisture from the air. Air-tight boxes are most desirable for this purpose, but under field conditions some other means usually must be sought. Most practical, perhaps, would be to carry along a supply of waterproof paper with which to wrap the packages. The paper must have a tough texture, however, and be large enough to allow generous overlapping at the ends of the package.

Waterproof paper can be made by dipping manila paper in melted paraffin. If paraffin is not available, waterproof paper can be made by the following formula:

Dissolve 1.8 lb. white soap in 1 qt. water.

Dissolve 1.8 oz. gum arabic and 5.5 oz. dry glue in 1 qt. water.

Mix the two solutions, dip manila, or similar, paper in mixture and then allow it to dry.

The standard practice has been to add a small quantity of either naphthalene or paradichlorobenzene (Paracide) to each package before shipping or storing. Naphthalene flakes are best for sprinkling over the specimens. These substances give some protection against attacks of insect pests, and some people believe that they also check the development of molds.

PACKING FOR SHIPMENT

In packing a large collection of plants for shipment, it is best to arrange the collection numbers so that they follow consecutively in each bundle. The individual sheets should be stacked neatly in piles; otherwise the specimens may be broken in subsequent wrapping and handling of the packages. The bundles ordinarily should not be more than 12 to 14 inches high when tied tightly. Each bundle should be protected top and bottom with a sheet of stout cardboard or equivalent material. The first strings are placed about 4 inches from either end, and the bundle afterward wrapped in paper. If the bundles are to go into a wooden or cardboard box this preliminary wrapping and tying will probably suffice, if the bundles are wedged with crumpled paper or excelsior to prevent shaking about. Single bundles going by mail or express need the additional protection of an outer layer of heavy wrapping paper. Wrapping should be done securely, and for long shipments it is sometimes advisable to sew a muslin cover over each bundle.

PLANT PRODUCTS FOR ANALYSIS

The basic information required for an analysis sample is the same as that needed for any other kind of collection, but supplementary notes and special information should indicate the need or desirability for analysis.

SUGGESTED NOTES TO ACCOMPANY SAMPLES

A-4280 *Sapium* (leaves)

Sangre de drago. 10 km. W. of San Martín de la Cruz, banks of Río Suciátemba. Depart. Cundinamarca, Colombia, S. Am. July 7, 1939. Natives use leaf decoction as cough cure.

A-4281 (roots) (2 sacks)

Orella de burra. 10 km. W. of San Martín de la Cruz, banks of Río Suciátemba. Depart. Cundinamarca, Colombia, S. Am. July 7, 1939. Used to kill head lice. Test for insecticidal properties.

A-4285 *Cinchona* (bark)

Quina. 20 km. E. of San Martín, Depart. Cundinamarca, Colombia, S. Am. El. 4,000 m. July 15, 1939. Apparently out of range. Not used by natives here. Test for quinine content.

As already indicated in the Introduction, analysis material should not be shipped except by previous arrangement with some particular agency, or person who is to make the analysis, and who, also, has given special instructions on preparing and shipping the samples. Usually about 5 pounds of material are required for an analysis, but the quantity might be less or more, depending upon the kind of product and upon the circumstances.

As a general rule, every sample for analysis should be accompanied by a good pressed specimen. It is important, too, that the pressed specimen actually come from the plant from which the analysis sample was taken. This is particularly true when critical studies are being made of the economic plants of a region. The collector not only must verify the accuracy of his information but also be certain that the information relates to a definite specimen.

When convenient, wood samples should be made from all important trees, especially those used for lumber or construction. A sample measuring about 1 foot long and 3 inches in diameter will suffice for sapwood, although a much larger one, including heartwood, is even better.

In preparing an analysis sample from any part of a plant—flowers, fruits, leaves, bark, or roots—a good thing to remember is that the material must be carefully dried to prevent mildewing or fermentation. If samples are small, they may be kept in cotton bags, but large quantities will require special instructions and handling. Resins, waxes, and juices also will call for special handling and appropriate containers.

PROPAGATION MATERIAL

As in the case of samples for analysis, the collector in the field should not attempt to accumulate propagation material unless he has assurance that some one will receive and give it proper care. Furthermore, he must be certain that the plant has sufficient interest or value to warrant the trouble and expense of sending it. As a matter of routine, pressed specimens for identification should be prepared to represent the propagation material when working with wild plants, or even with cultivated ones that are not well-known.

Aside from the usual collection data, he should include any fact or observation that will contribute to the successful establishment of the plant in the new growing place. The following are suggested notes: *Climate*—hot, cold, rainy, desert, length and time of seasons, occurrence of frost or snow; *habitat*—open place in forest, deep shade of trees, along stream, moist hillside, dry prairie, mountain slope, swamp; *soil*—rocky, sandy, silt, clay, well-drained, water-logged, degree of acidity or alkalinity.

SUGGESTED NOTES TO ACCOMPANY MATERIAL

P-4284 Grass (seed and roots)

San Martín, north edge of town. Depart. Cundinamarca, Colombia, S. Am. El. 3,000 m. July 10, 1939. Red clay soil, pH 6. Growing to 18 in. high where not grazed. Apparently resists drought and heavy grazing by cattle. Might make good pasture grass in areas free from frost.

P-4285 Cinchona (seedlings)

Quina. 20 km. E. of San Martín. Depart. Cundinamarca, Colombia, S. Am. July 15, 1939. El. 4,000 m. Steep rocky slope. Gravelly loam soil, pH 8. Apparently out of natural range. Withstands a long dry season, and tolerates poor dry soil. Might serve as grafting or breeding material to produce drought-resistant stock.

P-5002 Swietenia (seed and seedlings)

Cedro-y. Fazenda Itataquibinha on Rio Tapajós, 50 km. up river from junction with Rio Amazonas. Estado do Pará, Brazil. El. 300 m. Nov. 3, 1940. Mucky soil at edge of river, pH 6. One of the better timber trees of Amazon. Widely used in construction work and for furniture. Resists termites. Beautiful grain in wood. Would make valuable forest crop in tropical regions of high rainfall, in low ground subject to flooding.

Propagation material includes anything which can be used to reproduce a plant; it may be entire plants, seedlings, scions, budwood, stem or root cuttings, seed, bulbs, rhizomes, or fleshy roots. Material selected must be suitable for propagation purposes, and it must be prepared and packed to arrive in good condition. Many a shipment has reached its destination dead because of faulty packing. The method and kind of packing depends upon what is being sent and upon circumstances.

SUPPLIES NEEDED

Sphagnum moss, peat moss, charcoal, paraffin, waterproof paper, wrapping paper, tags, string, muslin, cloth bags, seed envelopes, sacking needles, gunny sacking, and indelible pencils are the usual items needed, but special conditions may call for additional or substitute materials.

A large flat bag, or basket, is a great convenience for carrying propagation material back to headquarters. Such bags and baskets are to be found in almost any market place in Latin America.

PREPARATION AND PACKING METHODS

Orchids, pineapple shoots, cacti, and similar plants require no packing other than a stout, well-ventilated basket, or box, to prevent crushing and rotting.

Small plants can often be moved from place to place during the growing season with no great difficulty, as anyone who has had gardening experience knows. Usually it is merely a matter of disturbing the dirt around the root system as little as possible and also of controlling the evaporation so that the plant will not wilt unduly during the operation. Often, under these conditions, plants can be transported considerable distances. With sufficient care, even young trees can be moved from the forest to a city plot. Under tropical conditions, fairly large seedlings of jungle trees have withstood a journey of 2 weeks or more. In a particular case, small wicker baskets were woven from split stems of tropical vines; the baskets lined with broad leaves; and the seedlings, after having been carefully dug up with a sizable clump of dirt about the roots, were placed in the baskets. About half of the leaves were cut off to reduce the evaporation of moisture; also the plants were watered frequently and kept in a shaded place.

To ship plants rooted in dirt is not always possible or even desirable, owing to prohibitive transportation charges, and because the soil may contain dangerous insects or diseases. In fact, the quarantine laws of many countries forbid the importation of soil. To comply with such laws, living plants can be grown in pots filled with sphagnum moss. They can be shipped long distances, even by sea, provided they are enclosed in a specially constructed box known as a Wardian case. This is nothing more than an oblong, stout box, tightly constructed, with a space at the bottom to accommodate the potted plants, a solid back, and a glass front. Two small openings, covered with screen, are placed at the top for ventilation.

A sort of miniature Wardian case was used successfully to ship small 2-inch forest seedlings from Brazil to Washington by air express. The seedlings were lifted carefully and the dirt removed; three or four of them were made into packets by surrounding the roots with moist sphagnum moss, wrapping securely in wax paper, and then tying tightly just at the base of the stems. The packets were attached to the inside of a small wicker basket, or a tin box with a portion of the side cut out to permit ventilation. An outer covering of thin cloth was sewed on.

Under winter conditions, almost any woody plant, even huge trees, can be moved about at will, but often it is necessary, or more convenient, to utilize sections of stems which can be used for grafting or budding. In many instances a plant can be propagated by using pieces of roots or stems as cuttings.

Shoots or pieces of stems to be used for grafting are known as scions, and they must be selected carefully from new growth to ensure getting vigorous material which will unite readily with the tissues of the plant upon which they are to be grafted. Budwood usually is selected from year-old stems which have vigorous-looking buds. In budding operations a small, thin rectangle of the stem bark is cut to include a single bud. This layer is removed and inserted into a small slit in the bark of

another tree. If the union is successful, the tissues will heal and the bud will develop into a branch. Stem and root cuttings are treated somewhat differently in that they are usually layered in sand to induce the formation of new roots and leaves. When these have developed sufficiently, the pieces are planted out as individual plants.

In general, pieces selected for scions, budwood, or cuttings must be not less than 8 inches long. They must be straight, clean-looking, and free from insect pests and diseases. They must be cut at a slight angle with a sharp knife to leave no rough edges. The cut ends can be dipped into melted paraffin to help conserve the moisture. The pieces are then wrapped together in damp (not wet) sphagnum moss so that each piece is entirely surrounded by the moss and so that no two pieces touch. If the moss is too damp, the stems will decay. Each lot is wrapped separately in stout, waterproofed paper, with the ends of the paper lapped over and tied securely to prevent evaporation of the moisture. If the lots are to be kept for any length of time, they must be further protected by a wrapping of moist gunny sacking and a second layer of waterproof paper. For shipping, the package may be inserted in a cardboard mailing tube.

In recent years, budwood and scions have been successfully shipped by enclosing them in cylinders of thin pliofilm. The method can be used only at a base where electricity is available, because the cylinders have to be sealed by a special electric iron. Scions and budwood are also reported to have been shipped safely in thermos bottles.

Underground portions of plants, like bulbs, corms, tubers, rhizomes, and fleshy roots, present no great difficulty in shipping, and in general will need only to be loosely wrapped, to prevent bruising, and to be packed in a container that allows plenty of ventilation. If small, they may be packed in dry peat moss within a box. Careful examination is necessary to make certain that such plant parts are free of insect grubs, or rots.

Many kinds of seed are easily gathered and shipped; they need no particular preparation other than cleaning from pulp, chaff, or other debris. Often, semimature fruits can be collected from the plants and placed in cloth bags to ripen, but the bags must be kept in the sun or over a gentle heat to prevent rotting or mildewing. All pulpy seed must be thoroughly washed and dried. Juicy fruits with numerous small seed may be crushed in water to separate the pulp from the seed. Chaff can be eliminated either by winnowing or passing through a wire sieve. Strawberry fruits may be crushed on pieces of blotting paper and then allowed to dry in a gentle heat.

Some delicate seed, such as those of citrus, palms, and mangosteen, for example, demand special attention to ensure germination. They must not be allowed to mold or dry out. They keep best when packed in tin cans, between layers of fine peat moss. Soft seed, like those of the avocado, will be preserved better if the peat moss is mixed with finely granulated charcoal. Charcoal checks the growth of molds and can be used to coat such fibrous and pulpy seed as those of the mango and some palms.

Seed sometimes are affected by atmospheric changes, especially at sea, and consequently must be protected during long shipments. This can be accomplished by wrapping the package securely in waterproof paper.

The propagation material should always be sufficient in quantity; generally speaking, the minimum should be not less than 12 scions, cuttings, or seedlings; 1 ounce of fine seed, such as tobacco seed; 20

large seeds, like those of the mango; 12 bulbs, like those of iris or onion; and 20 tubers, like potatoes.

Each separate lot of propagation material requires duplicate labels, one for the inside and one for the outside, each bearing the collection number and at least part of the data. All writing is best done with a medium-soft pencil. The inside label for cuttings or scions should be an eyelet tag, tied to one of the pieces. For bags and seed envelopes the inside label may be merely a square of paper.

DISEASED-PLANT SPECIMENS

A plant collector, especially in a foreign country, can render considerable assistance in the study of parasitic fungi if he will give special attention to the diseased plants he encounters. His notes and specimens will be particularly valuable in the case of economic plants, whether cultivated or wild, and especially so where new crops or new methods of cultivation are being introduced.

It is always desirable to know as much as possible about the parasitic fungi which occur on wild plants, because diseases are often spread from wild plants to cultivated ones. Still further, the fungi attacking a wild plant ordinarily cause little or no damage as long as the plant remains in its natural living conditions, but any or all of these fungi may suddenly become serious factors when the plant is brought into cultivation. This fact is well demonstrated in the case of the South American leaf disease of the *Hevea* rubber tree. The disease occurs naturally on wild rubber trees throughout the Amazon region and apparently has little importance under such conditions. However, attempts to cultivate the plant in seedbeds or in plantations sometimes have met with disaster by a sudden appearance of the disease. Young seedlings are especially susceptible, but even mature trees might be killed.

KIND OF DATA NEEDED

The name of the host plant is important and must be included in the notes. If the host is a wild plant or an unfamiliar crop plant, the collector will need to prepare a pressed specimen of it for identification purposes. Supplementary notes for parasitic fungi include any observations as to the extent of damage caused, such as slight, moderate, severe, percentage, etc.; and the effect upon the plant—leaf spotting, dieback of branches, cankers on branches or stems, root rotting, fruit decay, flower blight, etc. Photographs of diseased plants are desirable, especially if the symptoms are pronounced.

SUGGESTED NOTES TO ACCOMPANY SPECIMENS

F-5002 Leaf spot

On *Swietenia* (Coll. No. 5002)

Fazenda Itataquibinha, on Rio Tapajós, 50 km. up river from junction with Rio Amazonas, Estado do Pará, Brazil. Nov. 3, 1940. Affecting only lower, shaded leaves but causing considerable defoliation. Might become important disease if the tree were brought into cultivation.

F-5343 Dieback

On cult. rubber seedlings, *Hevea brasiliensis*.

Fazenda Perez, 4 km. S. of town of Bledo, near Belterra, Rio Tapajós, Estado do Pará, Brazil. Dec. 1, 1940. Eight plants affected in nursery of about 500 2-yr. seedlings. Tips die back about 6 inches, but recovery is made by new shoots below the infected region.

COLLECTING

Some degree of experience is required to collect good material, because many of the fungi causing plant diseases are almost microscopic. A few general hints, however, will enable any alert observer to contribute interesting specimens. Collect generous quantities of material.

The main or vegetative part of any fungus consists of a mass of fine colorless strands, known as mycelium. A well-known example is the cobwebby film which develops on moldy bread. In most cases these strands develop below the surface of whatever substance is being invaded by the fungus and consequently are not visible to the naked eye. After a sufficient period of time, the mycelium undergoes modification to produce spores. These spores serve exactly the same purpose for fungi as seeds do for the higher green plants. Spores are formed in various ways, depending upon the kind of fungus. Sometimes they occur inside definite structures known as fruiting bodies, which may vary in shape and size from minute, roundish pin points (figs. 30, *E* and 32) to large objects like toadstools, or woody, bracketlike formations sometimes seen on tree trunks or pieces of rotted wood (fig. 30, *A*). However, in some of the primitive fungi, the spores are not borne inside a definite body but may appear to the naked eye as a minute feltlike covering, or perhaps as tiny colored specks.

The specialist in fungi bases his studies on the structure of these bodies, and for that reason good specimens of fungi must include these mature stages. The larger fruiting bodies will be easily recognized, but for some of the minute kinds the collector may need a pocket lens of about 7 x magnification (fig. 32). Diseased plants can be recognized by a number of signs, but the symptoms vary according to the part affected and according to the kind of fungus.

Leaf spots (figs. 31, *A*, *B*, *C*) are a common manifestation and usually are seen as roundish or irregular areas of dead tissue, which may or may not be surrounded by a discolored margin. In some cases the dead tissue falls out, leaving a shot-hole effect, a characteristic, also, of some bacterial diseases. Leaf-blight (fig. 31, *D*) conditions occur when leaves are involved entirely and killed. In such cases the leaves may become detached and fall to the ground, or they shrivel up and remain in place. In twig blights, the twig and all the leaves attached to it are affected. Dieback is merely an intensification of a twig-blight condition, in that a considerable portion of a branch becomes involved, from the tip downward. Cankers (fig. 30, *C*) occur on branches, stems, or even on roots, and usually are represented by dead or discolored areas on the bark. If diseased bark tissue becomes enlarged to any extent, the condition may be known as a gall (fig. 30, *D*). Rots include any condition whereby a considerable amount of tissue is broken down by decay. A common example is seen in fruit rots (fig. 30, *E*), but stem rots, root rots, and wood rots (fig. 30, *A*) also occur. Mildews are recognized by small, grayish patches, usually occurring on leaves. Smuts (fig. 30, *B*), recognized by their black, sootlike appearance, usually attack the seed of grasses or cultivated grain crops. Rusts may appear either as minute, orange-colored cups, or as brownish or blackish slits, and commonly develop on leaves, although they sometimes are seen also on fruits or stems.

In many of these diseased conditions the collector may expect to find the fruiting bodies, or mature stages of the fungus, in the portion of the

plant that has been dead the longest, rather than in newly infected portions, that is, in dead shriveled leaves rather than in recently wilted ones; in blighted leaves that have fallen; in larger, decayed spots, instead of the smaller ones (fig. 30, *E*): and on the inner and older portion of a canker but not on the advancing edge. Leaf rusts and mildews

FIGURE 30.—Various examples of diseased plants. *A*, Bracket fungus attached to a piece of rotted wood (greatly reduced); *B*, smut of bamboo flowers; *C*, stem canker, young and old stages; *D*, stem gall; *E*, fruit rot; older stage at right shows minute dots which are the fruiting structures of the fungus.

occur usually on the under-leaf surface, and at times may be obvious from above only by a slight discoloration or yellowing, or perhaps merely by a slight distortion or crinkling of the leaf.

Workers in tropical countries will frequently encounter various kinds of insects which have been parasitized and killed by fungi (fig. 33). These interesting specimens should always be collected. They require drying over a gentle heat and then are packed in small tin salve boxes.

or the more readily available but fragile match boxes, with soft crumpled paper to prevent breakage of the delicate fungus structures.

All fungus specimens must be dried thoroughly before shipping. Leafy material is pressed and dried under pressure. Dead, or dry shriveled

FIGURE 31.—Various examples of leaf diseases. A, Tar spot of grass, frequent in Tropics; B, shot-hole leaf spot; C, zonate leaf spot; D, leaf blight; E, leaf disease of palm, common in Tropics.

leaves may be softened up before pressing by wrapping them for a while in a wet cloth or newspaper. If small enough, entire plants are collected and pressed. Large woody cankers may need to be chopped or sawed out. Large decayed fruits can be quartered, freed of pulp, and then

pressed flat for drying. In some fruit rots the diseased areas appear as circular spots of variable size (fig. 30, *E*). These can be sliced off, with a surrounding margin of healthy tissue, in sections $\frac{1}{8}$ inch thick and then dried in the press. Large fruiting bodies, such as the bracket fungi (fig. 30, *A*), associated with wood decay and tree rots, are collected whole and merely dried. Root rots are often difficult to diagnose, especially in small succulent plants. To make specimens of these, it may be best to collect the entire plant, or, if too large, then at least the entire root. Large roots may have to be sectioned.

After drying, the specimens may be left in the newspaper sheets or else transferred to large envelopes. Bulky material can be kept in paper or cloth bags.

FIGURE 32.—Leaf spot, highly magnified under hand lens, to show fruiting structures of the fungus as small mounds.

Plants often display symptoms or ailments which cannot readily be traced to a specific cause. Yellowing of the leaves might be due to a lack (or even excess) of certain chemical substances in the soil. A sudden wilting or drooping of the leaves might be assigned to lack of water, or to injury by some insect, such as a cutworm or stem borer. In fact, symptoms of insect injury are sometimes similar to those caused by fungi. The work of a leaf miner is often mistaken for a fungus leaf spot, but the characteristic tunnels and excavations of the miner, or the insect itself, usually will be revealed by holding the leaf to the light. Discolorations and crinkling of the leaves caused by certain mites and plant lice may be similar to those produced by certain fungi. Also, insect attacks

may weaken a plant to such an extent that it falls prey to some fungus, or the opposite might be true. Therefore the collector may need to do considerable detective work before arriving at the true conclusion.

FIGURE 33.—A wasp parasitized by a fungus (enlarged). Insects are commonly so attacked in the Tropics.

INSECT-PEST SPECIMENS

The general remarks on the desirability of collecting specimens of parasitic fungi apply equally well to insect pests. Any person working with plants can contribute valuable information and prepare good specimens even without a technical knowledge of entomology. One needs to have a keen vision, a degree of patience, and to know a few fundamental facts about insects.

Of the insects attacking living plants, the most frequently encountered will be beetles, weevils, butterflies, moths, grasshoppers, leafhoppers, ants, aphids (plant lice), true bugs (squash bugs), scale insects (coccids), flies, thrips, and white flies. Mites, eelworms, and slugs also cause damage, but these are not true insects.

The beetles, weevils, butterflies, moths, ants, and flies form one group (fig. 34, *A, B, C*) in that the adults differ in appearance from the young stages. The eggs hatch into wormlike objects (larvae), variously known as grubs, caterpillars, or maggots. After feeding for a time, the larvae go into a resting period (pupa stage) and pass through a complete internal transformation. Finally, the covering of the pupa splits open and the adult insect emerges.

In the other group (fig. 34, *D, E, F, G, H*), grasshoppers, leafhoppers, aphids, true bugs, scale insects, thrips, and white flies, the young stages (nymphs) are more or less similar in appearance to the adult form. The nymphs progress to the adult stage by periodically shedding their skins to emerge in a somewhat larger size. At each shedding they take on more and more of the adult appearance.

The nature of the damage to plants depends upon the type of mouth part possessed by the insect, whether chewing or piercing-sucking. Various types of injury are inflicted—externally, by chewing the leaves, buds, flowers, fruits, seed, stems, or roots; internally, by boring or tunneling in these same parts; and by piercing the plant epidermis and sucking out the sap. Sometimes injury occurs when an insect lays its eggs in some part of the plant.

In butterflies, moths, and flies, plant damage is confined entirely to the larval stages, because only the larvae have chewing or rasping mouth parts. In beetles and weevils both the adult and the larvae have

FIGURE 34.—Developmental stages in various kinds of insect pests. A, Seed-corn maggot: *a*, Maggot; *b*, pupa; *c*, adult fly (all enlarged). B, Cabbageworm: *a*, Egg (much enlarged); *b*, caterpillar; *c*, pupa; *d*, adult butterfly. C, Bark beetle: *a*, Larva; *b*, adult beetle (both considerably enlarged). D, Grasshopper: *a*, Newly hatched nymph (magnified); *b*, adult (about natural size). E, Leafhoppers: *a*, Two nymphs; *b*, adult (all considerably enlarged). F, Scale insects: *a*, Nymph, just hatched (all greatly enlarged). G, Aphids (plant lice): *a*, Young nymph; *b*, wingless, adult female; *c*, winged, adult female (all greatly enlarged). H, Squash bug: *a*, Eggs (natural size); *b*, young nymph (about twice natural size); *c*, adult (about twice natural size).

chewing mouth parts, and commonly both stages are destructive to plants. Both the nymphs and adults of grasshoppers have chewing mouth parts and likewise both cause damage. Leaf-cutting ants commonly destroy foliage in the Tropics, but in this case the plant material is not actually devoured but is carried to the nest to be used for growing fungi, which in turn serve as food.

Insects with the piercing-sucking type of mouth parts include the leafhoppers, aphids, true bugs, scale insects, thrips, and white flies.

In addition to the damage they cause by actually feeding upon plants, insects often are responsible for spreading plant diseases: directly, by carrying the disease germs from one plant to another, and indirectly by leaving breaks in the protective epidermis of the plant through which fungus spores can enter. For this reason, and as previously discussed, it is sometimes difficult to determine whether a plant ailment is due to fungi or insects, or both.

KIND OF DATA NEEDED

Aside from the general information (see p. 8), the collector should write down all pertinent facts observed, including the kind and degree of damage being caused and whether the insects were reared or caught wild. The elevation should be indicated, because it often has importance in the study of insects. If the plant being attacked is not a well-known crop plant, the collector will need to prepare a pressed specimen of it for identification.

The insect specimens will require careful labeling and numbering, to prevent mistakes and confusion, and special attention to the relationship between the various immature stages and the adult.

SUGGESTED NOTES TO ACCOMPANY SPECIMENS

- I-4281 Leaf scale
On tree (Coll. No. 4281)
10 km. W. of San Martín de la Cruz, on banks of Río Suciátemba, Dept. Cundinamarca, Colombia, S. Am. El. 1,000 m. July 7, 1939.
All plants seen were severely infested; causing decided yellowing of leaves but not defoliation. Adults with brownish, waxlike covering which flakes off to give a dusty appearance to foliage.
- I-5342 Root borer (beetle)
On cult. sugarcane. Fazenda Perez, 4 km. S. of town of Bledo, near Belterra, Rio Tapajós, Estado do Pará, Brazil. El. 300 m. Dec. 2, 1940.
Causing death of about 50 plants in an acre field. Both adults and larvae found inside the roots, and adults apparently feeding there. Two adults reared from pupae.
Photo 19-2 (showing longitudinal section of root tunneled by the grubs).

COLLECTING

The specialist who names insects nearly always needs the adult form, and frequently he may wish to see the immature stages as well. This being true, the field man, especially if he is in a foreign territory, who wants an insect pest identified, may be obliged to rear larvae or nymphs in order to get the adult stage.

Insect rearing is not always easily accomplished and may require time and considerable experimentation to meet the requirements of different kinds of insects. Pupae already formed can be kept in any sort of box or bottle which is covered tightly at the top with cheesecloth. Caterpillars, or other immature stages, can often be reared to maturity by placing them in a suitable container with a supply of their food. Large bottles might serve, although many students use old-fashioned lamp chimneys with the base pushed into a pan or pot of dirt and the top covered with cheesecloth. If the soil is kept moist, the branches of the food plant will remain alive for a longer time. Rearing cages made of screen or glass are sold by many entomological-supply houses. They can be constructed easily by nailing wire screen or mos-

quito netting over a wooden frame. The cage should have a hinged door and a solid floor to hold dirt.

Material for the identification and study of an insect pest should be generous in quantity, especially if the insect is new or little-known, and should include both adult and various immature forms.

A collector's net will be necessary to catch butterflies, moths, flies, and some beetles.

KILLING

Insect specimens can be killed by chemical fumes (in a killing bottle), or by immersing them in 75-percent alcohol, but neither method is suitable for all types of insects. Most collectors use cyanide for killing bottles. These can be made from any sort of a glass jar or bottle having a wide mouth and a tight-fitting lid or stopper. The glass should be thick enough to lessen danger of breakage. Either potassium cyanide or sodium cyanide may be employed, but both are deadly poisonous to all kinds of animals and should be handled with extreme caution. Several small lumps of the cyanide, wrapped in pieces of thin paper, are placed in the bottom of the bottle and then wadded down firmly by placing a circle of blotting paper on top. A layer of plaster of paris can be used to fix the poison in the bottom of the bottle. A cyanide killing bottle will last several years if properly prepared and used. Killing bottles can be made also by moistening wadded paper in the bottom of the bottle with carbon tetrachloride, ether, or chloroform, but this type of killing bottle needs to be recharged with the fluid at the beginning of each collecting trip.

If extensive collecting is contemplated, a number of killing bottles of various sizes will be needed, because it is never a good idea to mix many kinds of insects together in a single bottle. Each collection should be removed as soon as dead and kept separate in pill boxes or other small containers. For pickling in alcohol, a quantity of small vials and bottles of assorted sizes will be required.

PRESERVING

The killing-bottle method is best for adult stages of butterflies, moths, flies, grasshoppers, and true bugs. The last named can be kept in 70- to 75-percent alcohol, which serves also for beetles, ants, aphids, leafhoppers, and for all the immature stages of any insect. Caterpillars, and any of the larger larvae, will preserve best if killed by boiling in water for 1 to 5 minutes before transferring to the alcohol. The best preservative for thrips consists of 8 parts of 95-percent alcohol, 5 parts distilled water, 1 part glycerine, and 1 part glacial acetic acid. Collections of scale insects can be made by cutting off sections of the plant tissue with the scales attached and allowing all to dry completely.

Any specimen not preserved in liquid will need a thorough preliminary drying in the sun, or by artificial heat, before being stored or shipped. This is especially true for large specimens; otherwise they will be damaged by molds. Insects from the killing bottle need to be packed into final containers before drying; otherwise undue handling or shaking about will break off the legs and other appendages. Butterflies and moths are placed in individual paper triangles folded to fit the specimen. Loose specimens can be put into small boxes carefully packed with soft paper, or cellucotton, if this is available. Ordinary cotton should not be used for this purpose. Small paper cylinders are quite satisfactory as substi-

tutes for pill boxes and can be made in any quantity or size by wrapping a rectangle of paper around a pencil, a glass vial, or any similar cylindrical object as a form. The loose end is twisted shut, the insects are inserted, and the top is then carefully twisted shut to hold the specimens in position. The collection number, or other data, can be written on the side of the paper cylinder. Flaked naphthalene, added to the boxes in which the dried insects are stored or shipped, must not come into direct contact with the specimens.

Even pickled specimens need careful treatment. Never crowd a bottle with specimens or leave a large air bubble. It is best to fill the bottle with liquid or else to insert a wad of soft paper at the top of the container to prevent the specimens from moving about and becoming entangled with each other. For pickled material the collection data may be written with a soft pencil on a piece of paper which is placed inside the bottle. The stoppers of the bottles should fit securely to prevent leakage, and they may be dipped in melted paraffin for sealing.

PACKING FOR SHIPMENT

All the pill boxes, paper cylinders, and paper triangles should be packed separately in small boxes with sufficient wadding to prevent shifting about. Glass containers, vials, and bottles should be wrapped individually in paper and then packed securely in a strong box or carton, with cotton or wads of soft paper between, over, and under each item. These smaller boxes then go inside a larger box with at least a 2-inch layer, all around, of wadded paper or excelsior to give protection from rough handling of the package.

SUMMARY

This work is intended especially for the beginner who wishes to know how to prepare plant and insect specimens for study and preservation. It is written also for the enthusiastic layman who wants information about some plant or pest which has attracted his attention. Too often, he receives in reply to his query, not an answer, but merely an explanation that his specimen was too small, too dry, moldy, or otherwise inadequate. Frequently the opportunity to collect additional material has passed, or else the person still does not know just where he failed. Moreover, time has been wasted on both sides; the inquirer is disappointed, and the examiner of his material is regretful in not being able to supply the information desired.

The preliminary discussion points out that the essential and minimum information required is the same for all kinds of natural-history specimens. The collector should give particular heed to these general remarks as well as the more specific ones under the special headings.

The necessary points to keep in mind are: (1) Information desired; (2) name of collector; (3) where collected; (4) date collected; (5) adequateness of sample; and (6) proper preparation and packing to ensure arrival at destination in perfect condition.

Careful attention to the directions and study of the illustrations will enable anyone to prepare specimens sufficiently valuable to be added to scientific collections, where they will be available for future studies and investigations. This is particularly true in the case of wild plants which might become important as new crops, and also for the diseases and pests which occur on these plants.