APICULTURAL DEVELOPMENT FOR LOW INCOME NATIONS:

An Examination of Benefits, Costs, and Constraints.

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INTRODUCTION AND LITERATURE REVIEW

As low-income countries throughout the world search for means to eradicate poverty and human suffering, great attention has focused on the impact that full development of a nation's natural resources can have, in the attainment of a high degree of economic independence. In recent years, a valuable type of developmental effort has come under scrutiny, following recognition of the fact that no matter how poor the people within an area, an abundant, self-perpetuating resource exists: the nectar and pollen of flowering plants. Unlike other natural reserves, such as oil or minerals, neither human nor machine can efficiently collect these substances for processing and/or subsequent use. Rather, due to the minute quantities of plant nectars and pollens at each flower site, man must depend significantly upon a group of insects belonging to the scientific genus *Apis*, and commonly termed "honeybees," to do the collecting and processing for him. Through effective management of honeybee colonies, the products of beehives and the positive pollination effects of bees' presence in agricultural areas can function as an important economic stimulus. This paper will elucidate the economic value of the development of beekeeping throughout the world, emphasizing the special meaning such progress has for low and middle-income nations.

Although apicultural development programs are a fairly recent endeavor as far as international development assistance is concerned, man's interaction with the honeybee is by no means recent. Knowledge of the availability of bees' honey, pollen, and wax dates back to ancient times in the Old World, where it is believed the honeybee evolved and spread, long before the appearance of man. Early association between the two involved man's robbing of their nests, usually in hollow trees or rock crevices. This activity, termed "honey hunting," is depicted in a rock painting in eastern Spain, dated at approximately 7000 B.C., and attests to the ancient character of their interaction, as well as to the manner in which this activity was done. Honey hunting has survived from these Mesolithic times, and is still widely practiced today. (Crane, 1975a, p. 1). Ms. Eva Crane, present director of the International Bee Research Association, and international authority on bees and beekeeping, describes the history of this practice in the initial chapter of The Hive and the Honey Bee, a standard text in this field. Here, she distinguishes the transition from bee hunting to what could be called true bee keeping, and describes the latter as the stage when "man learned to safeguard the future of the colonies of bees he found in the hollow tree trunks or elsewhere, by a certain amount of care and supervision. Gradually, separate hives came to be used as substitutes for the natural dwellings of bees; for convenience and safety, they were collected in an apiary. Hive construction depended on what local materials were at hand, and on the local skills of the various communities. It is almost certain that the beehive had no single origin: it was an inevitable development in any region populated by honey bees, as soon as man advanced from hunting and collecting food to producing it, and thus started a settled existence." (p. 1).

Empty vessels of all kinds could attract wild colonies, thus eliminating the need for capture and transfer of wild colonies to man's own hives. Pottery vessels or clay pipes were used in the hot, dry country of the Middle East and north of the Sahara, or where trees were scarce. In forested areas, hollowed logs were made suitable for bee colonies, and then often hung high in trees. Whatever the technique, Crane describes all these hives as fulfilling certain necessary functions: "They protected the bees and their combs from wind, rain, and extremes of heat or cold; their flight entrances were small enough for the bees to guard; and there was some other opening through which the bee-keeper could get at the honey and wax which constituted his harvest." (p. 4).

Within the genus _Apis_ are four species of honeybees. Three of these are native to tropical portions of Asia: _Apis cerana_, often called the "Asian honeybee;" _Apis florea_, termed the "little honeybee;" and, _Apis dorsata_, known as the "giant honeybee." Of these three, the greatest success in colony management has been achieved with *Apis cerana*, notably in the nations of India and China. *Apis florea*, considered the most primitive of the honeybees, is also the smallest species, and builds a small, single-comb nest in the open. It is difficult to manage, but some success has been demonstrated by beekeepers in Oman, through increased understanding of the bee's behavior. *Apis dorsata* is generally hunted for its honey and wax, but is not kept in a hive. It also builds a single-comb nest in the open, but these nests are often reported to be as much as six feet long, and perhaps three feet wide. (Smith, 1960, p.9). The fourth species, known as *Apis mellifera*, is native to Africa and Europe; its native tropical subspecies *Apis mellifera adansonii*, is found in Africa, south of the Sahara, and is generally known as the "African bee." Some of these bees were accidentally released at a Brazilian research laboratory in 1956, and interbred with the more docile, "European" type of *Apis mellifera* then present, producing what is known today as the "Africanized bee." Since their introduction into South America, they have spread rapidly in all directions, and have been reported recently as far northward as Central America. It is the European type of *Apis mellifera* which is currently present in North America, some remaining parts of South America, and in the islands of the Pacific--all areas to which it was introduced, as no native species of *Apis* evolved there. *Apis mellifera* (including *adansonii*) prefers to nest in dark cavities, and constructs a multiple-comb dwelling. Much more in regard to the economic potential of these various species, in the face of current constraints, will be discussed at a later stage.

For the reader unfamiliar with beekeeping, it should be useful to briefly sketch some aspects of colony structure and function. First, it is important to understand that the individual honeybees within a hive are not significant in and of themselves; rather, it is the colony they cooperatively form which constitutes the crucial unit of concern from a management standpoint. The size of a single colony varies widely, especially among different species; but estimates range from approximately 80,000 bees, to approximately 20,000. Population size is self-regulated, as a colony can/will not expand beyond its resource capabilities. In this way, the availability of pollen, nectar, and water, which make up the bees' diet, strongly affects colony size; while other factors, such as the quality of the queen bee, and the overall health of the colony, are also important.

Honeybees may be one of three types: queen, worker, or drone. The queen is the only fully-developed female within the hive, and after mating is responsible for all egg-laying within the colony. Worker bees are also females, but are undeveloped; that is, they have not been reared on the rich diet a prospective queen receives, and therefore have very small ovaries. Workers form the bulk of the population, and carry out the essential duties which must be performed. These duties include comb-building, brood rearing, foraging, cleaning and guarding the hive, and cooling it by fanning their wings. They are also responsible for ripening plant nectars, through which process honey is made. Drone bees are males, and are the only ones without a stinger. They are anatomically stouter than queens or workers, but are generally not as long as queens. The drone does no work in the hive; he is fed by workers and responsible only for flying outside the hive, in hopes of mating with a virgin queen bee. If successful, the drone will die following copulation, as his abdomen is torn apart in the process. A queen is capable of laying either drones or workers, by controlling the spermathecal duct; this duct connects the queen's vagina with the sperm receptacle, called the spermatheca. A colony will rear the number of drones it desires, and will eject drone larvae when the queen has produced too many unfertilized (male) eggs. Thus, the drone population may range anywhere from several hundred individuals, to possibly a thousand or more.

Products of the hive are not limited to honey and beeswax alone. Economic value has also been attributed to bee pollen, royal jelly, propolis, and bee venom.

Pollen is collected from flowers, and subsequently stored in cells adjacent to the brood area. It is the bees' major dietary source of protein. Pollen "traps" can be placed on the hive to collect a large portion of the pollen loads the bees carry on their back legs, by making them pass through a wire mesh at the hive entrance. In so doing, the pollen loads are knocked off their legs and fall into the collecting box. Pollen is utilized for human consumption as a protein supplement, as it has been found that on average, its protein content compares favorably with that of beans, peas, and lentils. It is also quite rich in vitamins, minerals, and enzymes beneficial to human nutrition. Some pollen is collected from known plant sources, and purchased by pharmaceutical companies for de-sensitizing persons with pollen allergies. If a market for bee pollen exists in an area, there is no doubt that supplies could be collected on a tonnage basis, as is the case with honey. (Witherell, 1975). Royal jelly is a substance secreted by the hypopharyngeal glands of worker bees, and subsequently fed to queens, and to young worker and drone larvae, as an important source of protein. To the beekeeper, it is useful for the raising of queen bees. A limited market also exists for royal jelly, both in cosmetics and as a dietary supplement, although further scientific evidence is needed to document its therapeutic effects. (Witherell, 1975, pp. 546-547).

Propolis is a gummy, resinous material which is collected by bees from trees and other vegetation. It is used by the colony to seal open spaces where predators might attempt to intrude, or, in the case of feral (wild) colonies, it is deposited on the branch (or similar structure) from which the waxen combs hang. In this manner, ants and other crawling insects are prevented from reaching the nest. Propolis has a complex chemical structure consisting of waxes, resins and balsams, ethereal oils, and pollen. When cool, it loses its sticky character and becomes hard and somewhat brittle. Due to its anti-microbial properties against certain bacteria and fungi, propolis has economic value as a component in ointments and salves. It is also a principal ingredient in fine varnishes, especially those used by famous violin-makers in Europe. Scientists are still investigating the properties of this substance, increasing the likelihood that the market for propolis will someday develop. Beekeepers harvest this substance by collecting hive scrapings, obtained in the course of regular colony management. Due to limited demand, however, many beekeepers do not take the time to gather propolis and prepare it for marketing. Bee venom is another complex chemical substance, chiefly utilized by the medical profession for the treatment of certain types of rheumatoid arthritis, and for the de-sensitization of individuals who are extremely allergic to honeybees. The extraction of the bee venom requires special electrical equipment, seriously limiting the number of beekeepers who would become involved in its collection. In addition to the substances mentioned, one may also view the production of bees themselves as being of considerable economic value. Both Bodenheimer and Irvine report that in many countries in Africa, tropical Asia, South America, and parts of Australia, the larval and pupal stages of honeybees are consumed as food. (Bodenheimer, 1951)(Irvine, 1957). Studies on the nutritive value of brood have shown that they contain 15.4% protein, 3.7% fat, and large amounts of vitamins A and D. In fact, the vitamin D level ranged from 6,130-7,430 I.U./g. fresh weight, as compared to 100-600 I.U./g. for cod liver oil. (Hocking and Matsamura, 1960). Witherell cites numerous sources which document the value of brood as a food for fish, small mammals, and poultry, as well. (Witherell, 1975, p. 551). Gary estimates that if market demand existed (or were developed), "the average colony could spare about one pound of larvae every six days, over a period of several months." (Gary, 1961). Once harvested, brood can be used while fresh, or can be preserved through drying or freezing. The beekeeper may also realize economic gain through the raising of live adult bees for subsequent sale to other beekeepers as package bees (commonly sold in one and two-pound lots), nucleus hives (smaller versions of the standard hive), or whole hives. The raising of queen bees for sale is a delicate, but popular process as well. Thus, in addition to honey and beeswax, the development planner should consider the aforementioned products of the hive as potential contributions to income, whenever a prospective beekeeping enterprise is evaluated. In the course of this presentation, additional information on levels of production, world market conditions, and prices will also be discussed.

PART I: THE BENEFITS AND COSTS OF APICULTURAL DEVELOPMENT

In evaluating beekeeping as an activity or occupation worthy of adoption on an individual basis, as well as an important area for national development, one must effectively assess its costs and benefits. Such considerations have been articulated by most advocates of apicultural development, and their collective assessment of costs and benefits can be viewed as accruing to one or more of three general levels: 1) the individual; 2) the region; 3) the biological environment.

This author, in view of accumulated evidence, will take the position that the benefits of apicultural development far outweigh its costs, and will first present information relating to the benefits of such activity. Careful consideration of cost components will follow, again with special regard for the low-income situation with very limited resources. Then, in the face of these facts, a discussion of possible reasons for the current under-exploitation of apicultural resources will ensue.

A. Benefits

At the individual level, the benefits are extensive. Numerous articles point to the fact that in many parts of the world, beekeeping has been a traditional practice that is somewhat more readily adopted than a non-traditional activity. The Gourma people of Upper Volta, the Tiv of

Benue state in central Nigeria, and the Wakamba and Wadorobo peoples of Kenya are but a few examples of ethnic groups which developed specialists in this field. (Swanson, 1976a) (Ayoade, 1977) (Nightingale, 1976). Informed opinion does not suggest that apicultural development is feasible only among such accustomed groups; but rather, it illustrates recognition of the practice as economically valuable and of sufficient cultural importance to have been handed down through innumerable generations among many peoples. Where bee hunting has been the primary mode of activity, bands of honey-hunters have co-operatively sought feral colonies and shared the rewards of the search. (Smith, 1960, pp. 78-79). In modern times, collective approaches to beekeeping have persisted in many areas, and notably were promoted in Tanzania's Ujamaa development program. (Ntenga, 1976). In cases where traditional beekeeping was carried on as an individual or family-owned enterprise, hives placed at some distance from the home were usually distinguished from one another by the placement of certain family markings on each hive, to assert ownership. (Kigatiira and Morse, 1979). The facility, then, with which apiculture can be organized at both individual and collective levels stands as an important strength.

Other attributes focused at the individual level illustrate the flexibility of such an activity. Beekeeping is suitable for persons of either sex, over a wide range of ages. Children as young as eight years old, properly trained, could be responsible for tending the family's bees; likewise, elderly persons capable of only limited work could do the same, with occasional assistance with the heavier lifting.

An important benefit is realized in the minimal requirement on the manager's time, and on space utilized for hive placement. These two aspects facilitate integration of beekeeping with other existing activities, as apiculture does not, for the most part, compete with other necessary rural enterprises. The extent to which time and space factors should be taken into account when assessing operational costs will be dealt with in the section focusing on this and other cost factors. It is sufficient to note here that apiary visits are infrequent, and may be made when other work is not pressing. Relative to the space factor, beekeeping is quite suitable for even landless persons, often as a migratory operation. Programs designed to provide such employment for the ever-increasing numbers of transient, landless persons who face very limited, or only exploitative, employment possibilities, are sorely needed.

One of the most important benefits to the individual is the relatively small amount of capital required to begin a beekeeping operation, and thus, the low level of risk involved in doing so. More detailed estimates of costs will be outlined in the following section, with respect to the type of hive desired. Hives in many low-income nations are constructed from materials available at no cost to the beekeeper, such as reeds or straw, hollow logs, or clay pots or pipes. As explained earlier, the honeybees themselves forage for nectar, pollen, water, and propolis as the environment permits, once again at no cost to the beekeeper. Empty hives can be placed in locations where swarms are likely to settle, permitting the acquisition of honeybee colonies at no charge. Given successful management of procured colonies, a beekeeper can expect to build up the hive population to the extent that the colony can be split, resulting in two complete hives from just one. In this manner, one can expand his/her operation as time and interest permit, and management capabilities increase. In this way, financial risk is practically negligible, allowing persons with extremely limited disposable incomes to consider adoption of this practice.

Wherever honey production by subsistence-level persons is stimulated, one should not be surprised to find an increase in honey consumption within the home. It is therefore that one must consider the nutritive effect such use has on the individual. An Australian study presented in 1972, while acknowledging the importance of a balanced diet from basic food groups, cites research documenting the beneficial effects of moderate honey consumption. (Petrov, 1974). As scientists have increasingly appreciated the function of minerals and trace elements in the human body, respect for the nutritive qualities honey contains has heightened. It has been found to contain all of the essential trace elements, as well as useful amounts of minerals such as potassium, cobalt, iron, calcium, aluminum, magnesium, phosphorus, silicon, and manganese. The same study cites the World Health Organization's documentation of deficiencies of vital trace elements in poorer countries as much as twenty years ago, and the finding of similar needs by other researchers in both Europe and North America. Studies have shown that when honey is included in the diet of infants, the retention of calcium and magnesium from food was significantly higher. Other experiments with children have established that by including honey in the diet, blood hemoglobin was increased. This is possibly attributable to the iron, copper, and cobalt present in honey, for these elements are essential to hemoglobin formation. (Petrov, 1974). Eva Crane cites additional nutritional studies on the properties of honey, and reports on the vast quantity of literature concerning its antibacterial effects. (Crane, 1975b). Natural, unheated honeys have been shown to possess "inhibine," a bactericidal substance effective against both gram-positive and gram-negative bacteria, including Salmonella and the tubercle bacillus. Such pharmacological effects have induced many clinicians to utilize honey as a topical application in the treatment of burns and wounds. Crane says in regard to its attributes for this purpose, "the viscosity of honey makes it a good barrier compound, its water solubility allows easy removal, and its mild non-corrosive properties prevent any additional harm to either damaged or healthy tissue." (Crane, 1975b, p. 262). These positive effects suggest that honey, while not essential to one's well-being, can be a useful substance within the home, having a wider range of beneficial applications than do other sweeteners.

A report by J.U. Cabrera Pech of Mexico in 1977, to the XXVIth International Congress of Apiculture, focuses on apiculture as "an agent for helping solve the problem of nourishment of Mexico's rural populations," not only through advocating the consumption of honey over other possible sweeteners, but by encouraging the inclusion of honeybee pollen in the human diet. Pech cites the urgent need for higher levels of protein intake, and notes that the high production costs associated with animal foods places them out of reach to most of the rural population, due to low levels of income. Nutritional studies from various sources document the presence of numerous free amino acids, B-vitamins, niacin, pantothenic acid, vitamin C, and active cartoenoid constituents, the latter making vitamin A assimilable within the body. (Cabrera Pech, 1977).

Although the nutritive value of bee pollen varies somewhat, due to the different floral sources from which it is collected, Pech cites a report by S. Roman which quotes valuable evidence published by C. Hristea and N. Ialomiteanu in a report entitled, "Bee Products to the Benefit of Man's Health." Here, it is said that, "the essential amino-acid content of pollen is high, as it contains almost five times more isoleucine, leucine, methionine, threonine and lysine, and six times as much phenylalanine and tryptophan than an equal amount of beef, and three times more than cheese; and that if no other food containing amino acids were available, intakes of 15 g. on an average of pollen alone would be able to provide for the human daily requirements." (Cabrera Pech, 1977, p. 508). As noted earlier, pollen traps placed on beehives can net substantial quantities; in fact, Cabrera Pech notes that one type now being field tested in Mexico nets approximately 3 kg./hive each week. He also reports that while beekeeping practices are being spread, nectar and pollen potential is being assessed in these target zones, and research in this field carried on at the National Institute of Nutrition. In parallel fashion, consumers are being educated concerning the value of pollen and honey in their diets, and recommendations have been made to CONASUPO (National Commission for Assistance to Population) to develop foodstuffs with pollen and honey (or alternately by DIF, the Family Welfare component);

and to subsequently supply these products to rural persons at low, or even production, costs. Such activities show great promise, contingent upon the acceptance of the rural populace to incorporate pollen in their diets. Where this becomes possible, beekeeping promises to provide opportunities for improved nutrition, even in the most impoverished of areas.

Another benefit to the individual comes from the fact that once honeybees have finished their work in the hive, all subsequent processing of honey, rendering of wax, cleaning of pollen, and so on, can be done at home if desired. Furthermore, sophisticated technology is not needed to accomplish these tasks. Dr. I. Mann illustrates a suitable method for preparing beeswax for marketing, specifying that only a charcoal stove, several large tins (or an earthenware pot), two aluminum pans, a grass strainer or muslin-cloth bag, and several enameled or aluminum bowls are required. (Mann, 1958). Similar manuals have been designed in other countries to assist the individual beekeeper with the harvesting of his/her crop. For extraction of honey from its comb, the most basic of methods is to simply "wring out" the comb by hand, as one might do with a wet towel. Especially in areas working with the African bee, Apis mellifera adansonii, which is a prolific wax-producer, such a method will suffice if no other equipment is available. But where honey production is the main target, or where conservation of built-combs is a priority (as with *Apis cerana*)--as well as in areas where access to more sophisticated technology exists--beekeepers can fashion a simple honey extractor from a few basic parts, or purchase one from a beekeeping supply house. The honey extractor works as a centrifuge; once the wax cappings of the honeycomb have been removed with a warm knife, the combs are spun around, literally throwing the honey out of the comb and onto the walls of the extractor. Further straining and filtering is needed before pouring the honey into clean containers, but as is the case with beeswax, simple grass or wire strainers, or a piece of muslin cloth, will suffice. All particulate matter should be removed from the final products to ensure the highest price possible at marketing time. Where pollen is being collected, one will find that the pollen trap also contains some bee parts, such as legs, wings, and so on; these can be removed by winnowing, as one would with grain, or by passing the pollen through a wire mesh which will allow the pollen pellet to drop through, but retain most particulate matter above. Several such cleanings may be necessary, to obtain a relatively pure result. The materials and procedures described here are not all-encompassing, as there are numerous methods and materials which can be employed to bring about the desired result. Suffice it here to say, however, that the subsistence-level beekeeper is capable of processing his/her own hive products, with even the most limited physical and financial resources. This ability to effect a finished product within the confines of the home is a notable advantage over other agricultural situations, which may relegate the subsistence-level person to production of only raw materials, or other intermediate, unfinished goods, commonly at a considerable disadvantage in the price received at sale.

One important factor which must be stressed in regard to the preceding discussion, relates to the care with which processing of hive products is carried out. In many instances, improper handling of these products reduces their marketability, and subsequently discourages the beekeeper to continue the practice of keeping bees. In areas where the technical skills to properly process hive products are lacking, or insufficient, the establishment of processing and collecting centers will be detailed in the later portion of this paper; but here, it is important to note that the creation of such infrastructure can assist the beekeeper in receiving a satisfactory price for his/her product, and in maintaining the quality of the bee industry.

When properly handled, honey, beeswax, and pollen are not readily perishable commodities, and can therefore be marketed at the beekeeper's convenience. Even in cases where access to good roads is quite limited, little problem is presented. Hive products being of high value, the transportation costs incurred in getting to market can be more easily borne. Robinson quotes a 1979 USDA report, placing the value of honey on the world market at an average of $1000 per ton, while beeswax fluctuated at approximately $3500 per ton. (Robinson, 1980). As long as these products are properly stored, their value at market time does not decrease.

Finally, apiculture holds many benefits for the individual by means of its capacity to generate income. Richard Swanson, a development anthropologist with vast experience in West African beekeeping, describes this fact amply in his account of work with the Gourma people in Upper Volta: "A traditional grass hive costs its maker about $1.50 to construct, and lasts about five years. Properly processed, a beekeeper could gross between $15 to $45 per annum, per hive. This is significant, since the average disposable income among the Gourma is estimated at about $6 a year... Box hives coast approximately $10 to $15 to construct (using two hive bodies), but honey potential is greatly increased by their use, with proper care and management. In the two years in which such hives were in production, my records indicate that one colony in one year will produce a minimum of twenty, to a maximum of fifty, litres of honey. The minimum represents a gross yield of some $60 per hive, per year." (Swanson, 1976b, p. 195). Swanson notes that even the Gourmas, who are quite familiar with beekeeping, were surprised at the large income that careful management and processing would bring. Similar opportunities are described by other authors as well. The Development Foundation of Turkey, in its 1980 Annual Report, says of the possibilities of apicultural development, "Beekeeping offers almost a unique opportunity for increasing the incomes of small and poor farmers; and for creating employment and incomes for the landless villagers in rural Turkey. Wide regions of Turkey...are endowed with the type of flora which is suited for honey production, offering a good potential for working with large numbers of subsistence farmers in many regions." (Development Foundation of Turkey, 1980, p. 6). In a report by Dr. Gordon Townsend, University of Guelph, Canada, on the Ayiergweng Beekeeping Cooperative Society of Kenya, the impact of the integration of beekeeping into a subsistence-level farmer's operation is dramatized:

> In order to assess some of the results of the work of this cooperative, I visited...Albert Agongay-Opal. He had a small acreage, was doing some farming, and had a few cattle...He had four hives of bees and had started beekeeping with one hive in 1973. He said he was very pleased with the total operation, including the manner in which he was being paid by the cooperative. He said he intended to expand as soon as more hives were available and has saved enough money from his honey production to buy more hives. He harvests four times a year and obtains between 5 to 19 kg. per hive for each harvest. He cuts the comb out of the frames, puts it in a container, and takes it on a bus to the central refinery. The cooperative pays him between 6 and 8 Kenyan shillings per kg. for the honey and wax mix,

> depending upon the quality...He estimated that the four hives gave him about one-third of his total income. When the amount was calculated, the District Agricultural Advisor told me that this was equivalent to what he would receive if he worked seven hours a day for a full year, as a labourer. He feels that he could easily operate quite a number more hives because they are usually occupied (by swarms of bees) within an hour or less from the time he hangs one out.
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> We then visited the farm of Mr. John Okgenje. He occupied a similar type of land, but it was not nearly as suitable for farming. He had 25 hives, 18 of which were occupied at that time by bees. He had started in July of 1976. He purchased the hives through an A.F.C. loan of 1,800 Kenyan shillings, and has already paid back 300 shillings of this. He claims he now obtains his total income from the bees. From May, 1977, to the present time, January, 1978, he had already harvested three times. In one harvest, he was taking from 10 to 15 kg. per hive. He cuts the combs off the bars the same way as the other man, puts them in a container, and carries this on his head for four miles to the central cooperative. He seemed very happy with the whole situation, and, as I was leaving, he stated to me that he was convinced that bees are wealth. He expects to be able to pay back his whole loan in the very near future, and will likely be buying more hives.
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> The above reports are typical of many hundreds of others. (Townsend, 1978).

Dr. Townsend, a recognized international expert in apiculture development, reflects upon his experience: "Most development programmes by individual countries tend, of necessity, to be rather large ones, whose effects are far removed from the individual person within the country being assisted, except where they might by chance or arrangement be designed to assist some individual community... There are few projects which can reach back to the individual person within the country, particularly in the isolated areas where the help may be needed most. The desire of most of the assistance programmes is to try to raise the standard of living of individual people within the countries concerned...Beekeeping offers one such potential." (Townsend, 1976a, p. 115).

Moving now to ways in which apicultural development may benefit at the level of the nation-state, a recent comment by Dr. Eva Crane is most pertinent: "The facts and figures...show that bee husbandry at different levels already exists in virtually all developing countries, and that it still has a considerable unexploited potential. Existing methods can be made more effective, and improved methods can give higher yields. If hive products receive proper treatment and publicity, they will command higher prices, and there is a buoyant world market for both honey and beeswax. The minimal aim should be national self-sufficiency, for it is ludicrous that foreign exchange should be used to buy a commodity that is easily produced at home. (Crane, 1979, p. 15). Studies published by the International Trade Centre UNCTAD/GATT in 1977-8 state: "Fifteen countries, about half of which are developing countries, account for some 90 percent of world honey exports (with Mexico, China and Argentina together accounting for over 50 percent of total exports in 1975). World demand has increased in recent years...Supply has not been able to keep up with this increase in demand.

As a result, honey prices tripled between 1970 and 1974 and then stabilized at high but less than peak levels, and there is considerable export potential." (International Trade Center, 1977, p. iii). Also: "Beeswax is a high-value product; however, in many instances, its commercial value is neglected. The current shortage of crude beeswax, which is a result of reduced supply rather than increased demand, pushed up prices, bringing about considerable substitution by other waxes. However, certain properties of beeswax are unique, and it cannot be substituted entirely. The general consumer trend towards demanding natural products is likely to influence favourably the demand for beeswax, as is the growing demand for beeswax on certain non-traditional markets. Market prospects for beeswax from developing countries seem relatively good in the short as well as in the long run, and there is room for new suppliers. The market is expected to grow on a small scale if prices are kept at a reasonable level, and good-quality, unadulterated beeswax is supplied." (International Trade Center, 1978, p.iii). More specific factors influencing world trade in honey and beeswax will be discussed later in this paper. The point may be made here, however, that apiculture offers low and middle-income nations the opportunity to increase their foreign exchange earnings markedly, in a market where demand far exceeds supply. Most importantly, such gains may be effected at minimal investment costs.

A second benefit at the national level conferred by apicultural development is the generation of rural employment opportunities, especially in the area of skilled trades development. As beekeeping develops within an area, increasing the incomes of individuals who manage bee colonies, the market for beekeeping equipment can be expected to increase as well, as persons who once fashioned their own traditional hives become capable of affording more improved hive designs which can further increase production. Woodworking shops are needed to manufacture most types of hives now in use; while pottery industries are likewise needed in areas where a ceramic-type of hive is better-suited to the honeybees under management (as with Apis cerana). In areas where the Greek-basket type of hive is still promoted, basketmaking enterprises can be of assistance. Beekeepers also utilize certain metal implements, known as hive tools and hive smokers; these are of a simple design, are inexpensive to produce, and can be a useful product of village-level metalworking shops. In most cases, beekeepers protect their face and neck while working with their bees by wearing a bee veil. Local sewing enterprises can be induced to fashion these veils, as they require only some netting, elastic, and perhaps some strong cord. Beekeepers' coveralls may also be produced in these shops, as well as protective gloves for working with aggressive colonies. Lack of rural employment opportunities is an acute problem in most low and middle-income countries; thus, the fact that so many skilled tradespeople may be employed in the support of apiculture should be of interest to many governments dealing with such problems. Local industries may also develop around the products generated by beekeepers; packing plants may bottle honey for local consumption or export, while the availability of beeswax may stimulate candlemaking enterprises, or the creation of wax-based polishes.

Finally, benefits which accrue to the environment through apicultural development must be considered. Pollination of numerous fruit, seed, and tree crops by honeybees is by far the most important in this regard. Bees' presence in agricultural areas has a substantial economic effect as well, as the yields from entomophilous plants are significantly greater when sufficient pollinators have been present during bloom. At the Second International Symposium on Pollination, in 1964, M.D. Bindley pointed out that up to 20,000 different species of wild bee pollinators could be explored in relation to their potential as crop pollinators, in an attempt to ascertain the most useful types of insects for such purposes. (Bindley, 1964). In principle, this is true. But in more recent times, changes have taken place in our environment, sharply reducing the populations of wild insect pollinators. Virgin lands have been cleared for settlement, eliminating vast areas of once-rich forage; large-scale agriculture has encouraged the planting of extensive monocultures, which may provide bees with less-balanced nutrition; many nesting sites have been eliminated altogether; and, most dramatically, the increased use of insecticides without regard to their toxic effect on beneficial pollinators has created extremely serious problems. Thus, to ensure adequate pollination in agricultural areas, properly-managed honeybee colonies become absolutely necessary.

In an article entitled, "The Economic Status of Bees in the Tropics," Eva Crane outlines the characteristics which make *Apis mellifera* (as well as *Apis cerana*) a useful pollinator in modern agriculture: 1) its ability to utilize (pollinate) an enormously wide variety of plant species; 2) the fact that it builds large colonies (although those of *Apis cerana* are somewhat smaller), each of which can provide a foraging force of tens of thousands of bees; 3) its habit of nesting in an enclosed space, making it ideal for use in hives, which can then be managed by humans; 4) the ability to then move these hives from one agricultural area to another, where insects are lacking. (Crane, 1965, pp. 312-313).

Crane goes on to cite research documenting the increased yields among tropical crops, attributable to the pollination effect of honeybees. These crops include the following:

avocado, citrus, coconut, cotton, lychee, passion fruit, peanuts, and pyrethrum. (pp. 310-311). She also refers to an article in which Chapman discusses a similar effect in bananas, cocoa, coffee, mangos, pimentos, and acerola. (p. 310). Salah El-Din Rashad, an Egyptian apiculturalist, describes the use of honeybees for pollination of alfalfa, beans, squash, watermelon, sunflower, and sesame. These crops were grown in reclaimed desert areas, and the bees given supplemental feedings during dearth periods, to assure sufficient colony buildup for bloom periods of the crops mentioned. He comments on the results of these trials: "...Besides honey production, pollination of the cultivated crops gave yields improved in both quantity and quality." (Rashad, 1976, pp. 109-110). F.G. Smith presents a long list of fruit and seed crops which benefit from insect pollination. Important crops to tropical areas not mentioned by the previously cited authors are almonds, apricots, persimmons, flax, and cashews, as well as many others. (Smith, 1960, pp. 164-165). J.B. Free, a specialist in this field, lists numerous temperate crops requiring insect pollination, and clarifies in the text of his discussion the range of effects produced: "Whereas some crops give only a moderately increased yield when pollinated by insects, other crops give a greatly increased yield, and yet others yield little or no fruit or seed without insect pollination. However, more yield is not the only benefit that insect pollination can give. For example, adequate pollination not only sets more seeds... (of certain crops)..., but also more of the earlier flowers set seed, and produce an earlier and more uniform crop. Pollinisation may also affect the quality as well as the quantity of fruit produced; when it is insufficient, mis-shapen and lop-sided fruits are sometimes produced..." (Free, 1974, p. 151).

In recent years, apicultural development has allied with environmental programs which seek to reclaim vast areas of arid, and often over-grazed, land. Termed "agroforestry," these efforts are involved in the planting of legume-type trees such as Prosopis juliflora, Acacia mellifera, and Eucalyptus melliodora, which are excellent nectar-producers. Dr. Gordon Townsend, who has become involved in such projects, describes the benefits of such action: "The trees are producing both fodder and fuel, as well as fixing nitrogen in the soil. Some of these trees will grow as much as 20 to 30 feet in three to four years, and come into bloom with very little moisture requirement. They will open up vast areas not being used at the present time to both beekeeping and livestock production. Of particular interest for such development is the Sahel region of Africa, and some of the coastal areas of Chile and Peru." (Townsend, 1981a, p. 179). The prospects for integrated programs such as these will be expanded at a later stage of this presentation; but readers should here note the economic promise inherent in these endeavors, concurrent with environmental benefits.

B. Costs

It should be apparent from the preceding inventory of benefits that the positive effects of apicultural development are both numerous and widespread. One must next contrast these benefits with various cost factors, to arrive at a full appreciation of the net value of such a venture.

At the individual level, the cost of establishing an apiary is contingent upon the scale of the enterprise undertaken, and the style of management practiced. A newcomer to beekeeping, with little personal capital to invest, may wish to begin with just one or two colonies, until evidence of profitability is shown and confidence in managerial ability is gained. Since "modernized" hive designs are usually more expensive than those "traditional" types, made from logs, clay pots, straw skeps and so on, a beginner may choose to start with a traditional hive, and then utilize the profits to purchase improved equipment.

An example from Botswana demonstrates the extent to which one may construct a beehive out of salvage materials, at a cost of approximately $2.50. Mr. Bernhard Clauss, in A Beekeeping Handbook, describes the making of a cow-dung hive from a strong cardboard box, in about one week's time. (Clauss, 1980). Five parts fresh cowdung is mixed with three parts clay, adding water as needed to make a good mortar. Several sticks are fitted across the width of the box to keep it from buckling, once the cowdung mixture is applied. The exterior of the box is smeared with the mixture, and left to dry for three days; the same procedure is repeated once more, and again given three days to dry thoroughly. Finally, any cracks are filled, and the supporting sticks are removed. Entrance holes are then drilled at the lower portion of the front of the box; and enough top bars are cut to cover the top of the box completely. Several sacks and/or a sheet of plastic may be placed over the top bars, to provide some insulation and protect the hive from the rain. Since this type of hive will not stand up against much rain, Clauss suggests that some type of "trestle" or shade be constructed overhead; this serves a dual purpose, as it will also protect the colony from intense sunlight. This type of design is comparable to the "Kenya top-bar hive" now recommended in Kenya, as well as in other areas where the modern "Langstroth" box hive is less suitable. Estimates on the cost of the self-made cowdung hive assume that the cardboard box, clay, and cowdung can be gotten at no cost; while the wooden top bars, and some wax with which to coat them, may cost 2 pula--(approximately $2.50). It is also assumed that the hive's protective covering utilizes whatever is on hand,

and thus costs the beekeeper nothing. The manual compares the cost of this cowdung hive with a wooden top bar hive, which can be purchased in a nearby town. Two types are available; a complete hive with "wooden ridges" to support the honeycombs costs 40 pula (approximately $50), while a somewhat cheaper version, with "wax ridges" applied by the beekeeper, costs 25 pula (approximately $31.25). Occasional repairs to the wooden hives (nails, screws), and a coat of paint every two years or so is estimated at 3 pula ($3.75). This comparison of costs effectively demonstrates the savings involved in the self-made hive, which explains precisely why the number of traditional hives far out-numbers that of more modern designs, in most low-income countries. Clauss's cowdung hive is particularly ingenious because it combines the use of available materials (and thus low investment cost), with the improved hive design inherent in the "top-bar" approach. More on transitional beekeeping technology will be said in a section dealing with developmental constraints. But it is important here to understand that in situations where investment capital is extremely limited, an interested person can still make a start in beekeeping. As more capital becomes available, better hives can be built or purchased, and the entire operation expanded. As in many other types of agricultural endeavors, there are always more sophisticated, more costly ways of doing things--and beekeeping is no exception. Clauss does not include costs for protective clothing or a bee smoker; the former may be considered by those who do not mind bee stings as a luxury, or simply not essential. But some type of smoker is nearly always used to calm the bees; and Clauss's no-cost variety is simply a tin can with the lid bent backward, filled with dry sticks, leaves, and so on. The smoke is then held in front of the hive, and blown inside by the beekeeper.

Depending upon local bee population levels, the bees to populate an empty hive may or may not have to be purchased. In regions where colonies readily abscond, leaving their hive for a new home, or where bee swarms are common, it is not likely to be difficult to obtain a colony at no cost. But where this is not the case, one may have to incur such an expense. The price varies widely from one location to another, but is relative to the extent of scarcity and the seller's own cost factors.

Once the apiary is established, workers in the colony will begin foraging for food after orientation to the hive has been accomplished. As long as enough nectar and pollen sources are available within foraging range, food shortages are not likely to become a problem, as the workers will not rear more brood than current resource inflows dictate. Problems can arise, however, if dearth periods occur for too long a time and the colony lacks enough stored honey and pollen to outlast the food shortage. In tropical areas, such dearth periods may induce absconding, causing an economic loss to the beekeeper, since colonies are likely to consume whatever honey is stored within the hive before they leave. But in other cases, especially in temperate areas when temperatures are too cold for the bees to fly, the colony may simply die of starvation once food stores have been exhausted. Therefore, it pays a beekeeper to know as much as possible about the nectar and pollen sources in the area, to observe local weather conditions, and to be aware of the extent to which the colony has sufficient food to weather such dearth periods. In some cases, supplemental feeding may be required, and this may mean some additional cost to the beekeeper. Sugar, commonly fed in syrup form, may be fed to the colony if desired, or when there is no honey available. Thus, the cost of sugar is an integral factor here. If brood rearing is to continue, pollen must also be fed. If this is unavailable, some other protein supplement, such as soy flour or brewer's yeast formulations, may also be used. In any case, the proximity and availability of nectar and pollen sources is a primary factor for consideration, and may result in economic loss or unanticipated costs, if neglected.

Honeybees, like all other forms of life, suffer from disabling diseases of various kinds, as well as numerous pest infestations. Some diseases, such as Americal foulbrood disease (AFB), spread so rapidly from one colony to another, and are therefore so dangerous, that the affected colony (at the very least) may have to be destroyed. Others, such as European foulbrood (EFB) and nosema, weaken the colony to the extent that it becomes unproductive, and may eventually die. Pest such as the acarine mite, *Acarapis woodi*, and the external mite *Varroa jacobsoni*, can reach levels of infestation so high that the colony eventually succumbs. Thus, the beekeeper needs to be aware of local disease problems and pests, and to be able to spot them in his/her own hives. Once identified, some type of treatment is often available, but here again may result in an additional maintenance cost. In many countries, the cost of medicants to control bee diseases may be subsidized by governmental agencies, and thus made free of charge or available at very low cost. A novice beekeeper would therefore be wise to ascertain the incidence levels of bee diseases in the region, and be aware of the costs to his/her operation if they should occur.

If the processing of hive products is carried out within the home, the cost of necessary implements must also be considered. As previously discussed, most processing can be accomplished effectively, utilizing materials already on hand. If this is the case, or if processing is done at some central location, then costs of this kind need not be included.

In nations making an earnest attempt to develop an apicultural industry, regional collection centers are being designed to handle the honey and beeswax of numerous local beekeepers. Where this is the case, the individual beekeeper may incur some cost of transportation to this location and back home. An important factor, then, is the price a beekeeper receives for his/her product; the price must be sufficiently high to encourage the individual to bring these products to the collection center, regardless of the cost of transportation in doing so. Further aspects of product prices and rationale for support of the regional collection center concept will be dealt with in greater detail at a later stage. The point here is that the availability and proximity of markets and/or collection centers largely determines the beekeeper's transportation and marketing costs, and is an important consideration from both the beekeeper's and the development planner's point of view.

In cases where the beekeeper owns no land, or must locate his/her hives away from the homestead to take advantage of better floral sources, the possibility of having to pay for apiary space exists. In most cases, the returns received from operating even a few colonies successfully is sufficient to permit payment of such a rental charge; but a review of the literature does not suggest that costs of this kind are a very frequent occurrence. One reason for this is the fact that the pollination services provided by the bees are beneficial to growers in the area; and in fact, it is the beekeeper who sometimes receives payment for locating colonies in an entomophilous crop. Another possible reason is due to the prevalence of common ownership of land, often eliminating the need for payment, as long as the land is being used beneficially. In cases where hives are located in trees, or the exterior wall of a house, or atop buildings, no actual land use is involved, which may again dispense with the need for rental of apiary space. For many of these reasons, beekeeping has been viewed as occupation that even the landless person may find feasible.

Although the limited amount of time required to manage several colonies of bees has been described as a considerable benefit, nevertheless, the charge for the beekeeper's time must still be taken into account when computing total cost. The extent to which one expands the number of colonies within the apiary is, of cource, a primary factor in the total time requirement; and a person who wishes to keep several hives to only supplement his usual income will not be expected to be pressured by the hours essential to their profitable management. But, the individual who is convinced of beekeeping's profitability, and wishes to adopt it as a full-time occupation, must consider the limits of his/her labor productivity, to establish the maximum number of colonies which is feasible. M. Oksman of Argentina discusses the time/labor constraint for the "common beekeeper," which he defines as, "the one who owns an apiary, performs all operations by himself alone, and earns his living from it." (Oksman, 1973, p. 577). Oksman accurately points out that during the beekeeper's busiest season(s), s/he is involved in two basic activities: the first is the maintenance of colony fitness, while the second is the extraction of honey (as well as the processing of other hive products). As has already been briefly discussed, the beekeeper may have the assistance of a regional collection center at this second stage; or, may have found it worthwhile to purchase a small extractor, to hasten the performance of this task. In either case, mechanization can assist the beekeeper with the duties of harvest, resulting in considerable savings of time and labor. It is the first stage, however--the colony management process--for which no mechanical substitute will suffice. The keen eye of the experienced beekeeper is an irreplaceable asset; and the physical manipulation of colony conditions is adequately termed the necessary "human cost" of production. The possibility of employment of seasonal workers is, for the small-scale beekeeper, considered out of the question. Oksman says in this regard that, "the common day worker refuses to handle bees, and the one capable to do it--supposing we find one--demands very high wages. Consequently, the method which causes the common beekeeper to hire workers for the operations during the first stage, can by no means be suitable to his requirements." (p. 577). Thus, in seeking the maximum level of productivity per beekeeper, Oksman advises systematic simplification of management techniques, to capitalize on those colony functions the bees themselves are most capable of performing, without the extensive involvement of the beekeeper. Without specifically detailing these management strategies, it should suffice to say that minimization of time spent on colony maintenance should be an important goal, without sacrificing profitability. Techniques used to accomplish this balanced state will certainly differ from one apiary to another; and to this end, it is the beekeeper's responsibility to experiment, to find out what interventions are most cost-effective. Once a high level of productivity has been reached, the issue of how to value the beekeeper's time/labor still remains, if desiring to calculate the total cost of production. International congresses of apiculture have discussed uniform methods for its calculation; but methods for computing the various components of the total cost of production are not described in sufficient detail to make practical use of them, (Cornejo and Itzcovich, 1969) (Cornejo and Itzcovich, 1973), nor do they appear to have received wide acceptance, and thus will not be detailed here. One reasonable approach would be to value the time/labor of the beekeeper at his/her opportunity cost, since such a method would account for the income earned in the best alternative employment to beekeeping. Perhaps one stage of apicultural development will see the application of the budgeting and planning techniques used in farm management, to the beekeeping field; but at this time, well-agreed upon methods which can be used in many types of apicultural situations are not apparent.

The ease with which an individual may begin beekeeping, despite limited investment capital, has been pointed out in the preceding discussion. However, in some development programs, credit has been made available to assist interested persons in getting started; and, in programs requiring that some percentage of the loan amount be paid as interest, this too must be considered an additional cost of production. More information on different approaches to the extension of credit to beekeepers in low-income nations will be discussed at a later time.

Finally, one may wish to consider the production risks associated with an investment in beekeeping as an element of cost. As in any agricultural endeavor, there are numerous risk components: weather, disease, catastrophe, and even human attitudes--such as discovery that one dislikes beekeeping, and wishes to discontinue the practice. In any case, risks will vary from one location to another; just as the amount of risk an individual is willing to bear differs from person to person. As pointed out earlier, it is the minimal cost of investment on a small scale, which helps to make beekeeping an attractive risk for the low-income person.

In review of the possible costs of production to the individual beekeeper, one may note that they can be kept to quite a strict minimum, where desirable, while still preserving the opportunity for considerable economic progress. In many cases, the situation is made easier for the interested individual when some concern for apiculture is demonstrated on the part of the national government. In the following section, aspects of the costs incurred at this level of involvement will be discussed.

One of the most active promoters of apicultural development among the world's high-income nations is Canada, chiefly through the Canadian International Development Agency (CIDA). Dr. Gordon Townsend, who has worked through CIDA on many projects in international apicultural development, describes the cost constituents of a successful program: "1) An agreement with the country concerned, that it is interested in the long-term development of beekeeping, and is willing to supply personnel, buildings, and operating funds; 2) Training of junior personnel for extension purposes; 3) Training of a Director for the programme, and a back-up--preferably at University level; 4) Provision of an administrative headquarters, laboratory, and teaching accomodation, and vehicles for transportation; 5) Establishment of a woodworking and tinsmithing workshop, and training of personnel to make beekeeping supplies; 6) Establishment of honey collection centres and, if necessary, a central honey-processing plant; 7) Provision, if possible, of revolving funds, or some other means of purchasing honey and beeswax as it is produced." (Townsend, 1976a, pp. 115-116). Townsend goes on the say:

> "A feasibility study should be made prior to the signing of a contract, to learn about the availability of trained personnel in the field, what facilities and interest the government already has had in the programme, and what other agencies are already active, as well as the successes and failures of earlier programmes. An estimate is made of the potentials of certain areas within the country, and of the traditional beekeeping practices. It is also important to know what type of financial organization the government of the country prefers: cooperatives, private, government operation, etc. Once these points are established, an outline is made to show how a programme might be started in the country concerned: each country must be looked at from a different point of view....
>
> In Canadian programmes, Canada is usually willing to provide the following: equipment, such as vehicles, laboratory supplies, woodworking and metalworking supplies; travel and tuition for individuals for training; and, in some cases, costs of attending conferences, provision of Canadian experts when they are considered necessary, and consulting services throughout the programme. The above will be provided only if the government of the country concerned signs an agreement: to establish within its budget a programme in apiculture; to provide housing for the above equipment; to train staff in order to operate the programme; and to maintain and operate vehicles and other equipment. In all cases, the materials and services supplied have been a straight grant

to the country concerned. However, the spending and the purchasing are carried out by CIDA, often through a consultant or a project director in Canada who is always in direct contact with the person in charge of the work in the country concerned." (pp. 116-118).

The immediate emphasis on training can be seen from this description; this stems from the aim to establish self-sufficiency of direction in approximately four years. Where no organization of leadership in apiculture exists, several Canadians are usually sent for at least the first two years of the program, to establish an administration center, office space, laboratory set-up, and teaching area. The woodworking and metalworking shops are then equipped, and persons are trained to manufacture the types of supplies needed. Simultaneously, local personnel are recruited and trained in beekeeping, in preparation for carrying out extension work. Those who show superior skill and interest will be selected for additional training in a formal program, either within the country or elsewhere. The two best candidates for directorship of the national program are then sent to the University of Guelph, Canada, to secure training in apiculture at either the Master of Science or Ph.D level. Their program is planned in such a way as to permit them to return to their country approximately six months before the end of the initial four-year phase, shortly after which time the Canadian personnel will depart. This foundation having been laid, phase two will usually concentrate on training back-up staff, and further expansion in targeted areas.

If, on the other hand, trained apiculturists are already available in the country concerned, Canadian specialists will visit on a short-term basis only, as specific problems require their assistance. One of these persons will be appointed as official consultant to the project, and will visit at least once a year with government leaders, in order to discuss past results and plan strategies for the following year.

The Canadian approach has been developed through many years of experience, and has been found very successful, most notably in the case of Kenya. Kenya is presently in phase two of its national program in apiculture, and is now developing extensive training facilities which will enable it to become a source of information and education for the entire African continent in this field. Townsend says of their progress: "...Our work in Kenya started from primitive beekeeping in 1971, and is just now reaching the stage where they are able to cut off imports of honey. They will be thinking about export over the next three or four years, if the present trend of production and interest continues." (Townsend, 1981a).

The rationale behind the insistence on development of honey collection centers lies largely in concern for the economic value of the beekeepers' products, which is markedly decreased through mishandling. Many traditional hives are one-chambered structures, which require the bees to keep their brood, wax, honey, pollen, and propolis in the same area. (In contrast, more improved types of hives separate the brood area from the major honey-storage area, allowing easier removal of honey for extraction.) Townsend comments on the nature of this problem: "Often, in order to separate the honey from the wax, the whole mixture is heated over an open fire, with consequent burning and smoking. As a result...thousands of tons of honey every year...is usually badly prepared, and unattractive in appearance. Because of this, its place in the local market is taken by imported honeys. If...properly prepared and distributed, there is no doubt that a ready, local market would be available." (Townsend, 1976b, p. 85). Townsend notes that in East Africa, where traditional beekeeping has long been popular, the honey collection center concept has often met with failure, after a few years of buoyant success. In studying the reasons for lack of sustained progress, Townsend states: "The main requisite for success seems to be a strong, central marketing organization, or a government section responsible for the overseeing of apiculture developments within the country. In this way, the organization can be assisted over its rough spots, and necessary supervision of the technical operations provided. The ideal organization would appear to be a central processing and packing plant, supported by satellite collection centres in the main areas of production, backed up by a government extension service of well-trained personnel." (p.85).

Further aspects of the development of collection centers will be elaborated upon at a later stage. At this time, it is important to appreciate the importance of national organization in the development of apiculture in the areas mentioned, to permit assistance to small-scale beekeepers in improving product quality, level of supply, prices, export potential, and so on.

The cost of development at the national level will, of course, depend upon the nature of the program desired, and the success with which external assistance is obtained, if this is desirable. As the successful program of Kenya has already been described, it may be further illuminating to specify the initial costs of phase one in their development effort. (see Table 1) It may also be noted that over the entire period, Kenya had invested slightly more than had Canada; but Canada's support was particularly heavy during the first year of the project, precisely at the time when Kenya most needed it. Kenya's contribution has been increased in each year's budget, over the course of phase one. To the minds of some, this manner of external assistance is particularly valuable in its method of steadily increasing Kenya's degree of self-reliance in developing its apiculture program. In Kenya's initial proposal to CIDA, "reasons for wanting to develop the apicultural industry" at the national level are explained:

Table 1. KENYAN APICULTURAL DEVELOPMENT PROGRAM-PHASE I

ASSISTANCE REQUIRED FROM THE CANADIAN GOVERNMENT

Staff	1970/1	1971/2	1972/3	1973/4
2 Apiculturists	(2)	(2)	(2)	(2)
Fellowships	(1)	(2)	(2)	(2)
Buildings				
Laboratory & Office	K.Sh. 10,000	-	-	-
Equipment & Vehicles				
Lab Equipment and Demonstration hives	1500	300	300	200
Field Demonstration Equip. Pamphlets	300	300	300	300
Vehicles (2)	1800	-	-	900
Travelling	800	800	800	800
TOTAL:	14,400	1400	1400	2200
1970-74 GRAND TOTAL:	19,400			

KENYA CONTRIBUTION

Staff	1970/1	1971/2	1972/3	1973/4
2 Counterpart Officers	800(1)	1600(2)	1650(2)	1700(2)
12 Instructors and Lab Staff	1210(6)	1820(9)	2300(11)	2540(12)
1 Clerk	240	260	280	300
Other Charges				
Upkeep of Laboratory	-	300	400	400
Demonstration Equip.	100	100	200	200
Stationary (inc. leaflets)	100	100	100	100
Subsistence & Travelling for Instructors	180	300	400	450
Subsistence & Travelling for Kenya Officers	300	-	-	400
TOTAL:	3930	4480	5330	6090
1970-74 GRAND TOTAL:	19,830			

Note: Figures in parentheses indicate personnel needed; all others are in Kenya shillings.

1. To meet the existing and increasing local demand for honey for both beer and good quality honeys. At present, over 50,000 Kenya shillings worth is imported.

2. On nutritive grounds it is desirable to develop a village market for honey. Experimental work has shown that there is a demand for this product if it can be sold at about K.Sh. 2 per pound, or thereabout, in competition with the cheapest local plum jam...Work to-date indicates that a cottage industry could produce it at this price.

3. Increase export earnings by producing more wax. Present earnings could probably be doubled. At a later date, develop specialized export markets.

4. Provide an increasing income for the traditional honey gatherers who use forests, and who have no other source of income. At the same time, develop the full honey potential of these forests. Professor G.F. Townsend, in a report on Beekeeping in East Africa (1969), suggests that production of honey from suitable forest plantings could be worth at least half or more of the timber value per year.

5. Maintain the income of the honey and wax producers in the marginal agricultural areas, who are so much in need of this income.

6. Provide a new income opportunity for small-holders in the agricultural areas, whose acreages are too small to provide sufficient for their subsistence and cash requirements.

7. Develop an apicultural industry which serves the crop industry. In other countries where it is estimated that 80% of the pollination is done by bees, major increases in yields have been obtained from many of the crops Kenya grows and is trying to grow. Examples are given elsewhere of some horticultural crops having their yields increased from 50% to 160%...

8. The development of a major apicultural industry would almost certainly double the present income to the producer through better marketing, organization, and increased yields per hive. Improved marketing, for example at Marimanti, has already increased returns for Grade I honey from 80 cents per pound to K.Sh. 1.30 per pound, (a 50% increase), and Grade III honey to 90 cents per pound minimum...One day, with migratory hives, perhaps some growers could reach the Australian figure of 100 pounds per hive, achieved by some specialists...

> It is quite clear from recent experiences in Kenya...and the experience of other countries, that in order to benefit from a thriving apicultural industry, the Ministry of Agriculture must have a properly-staffed and qualified Apicultural Section, to deal with the problems on a full-time active and continuing basis...It is essential under the present Government structure that the Section be placed in the Ministry, in order to utilize the considerable existing resources of that organization, and also be in a position to execute policy. Failure to establish such a section at this time will only waste the money and time that has been spent during the past three years (in pilot projects)...(Kena Ministry of Agriculture, 1970, pp. 4-5, 7).

Hopefully, the inclusion of this in-depth presentation on the Kenya situation will elucidate the rationale behind investment in apiculture at the national level, and will give the reader some appreciation of the relative scale of the expenditure, for both the assisting agency and the host country. At a later stage, supplemental information on supportive institutions for development of apicultural potential will be presented.

Finally, this section must consider the environmental costs of beekeeping, as it is practiced in many of the world's low-income nations. Fortunately, a review of the literature reveals only one harmful practice perpetuated by beekeepers, seemingly unaware of its dangers. In the course of traditional hive construction, some beekeepers in forest areas girdle specific types of trees--that is, they cut and peel away a large section of the tree's bark--and subsequently bend it into a cylinder. In this manner, they destroy the tree in the process of making their hive; and worse yet, often the trees chosen for this purpose are valuable honey trees (good nectar and/or pollen producers). (Townsend, 1976c). Where attention is being paid to the activities of beekeepers, the harmful effects of this practice are being communicated. Moreover, other inexpensive alternatives are being made available to these beekeepers where possible, to reduce the damage of trees in this manner. Reports do not indicate that the practice is widespread; but in areas where it is common, the environmental danger to beekeeping is considerable. In contrast to the environmental benefits, the cost of mismanagement of this sort appears quite small.

Reflecting on the net value of apicultural development, the question arises as to why the overwhelming benefits of such effort have for so long been ignored by many international "experts" in agriculture. In this regard, comments made by Richard Swanson to the 1976 International Conference on Apiculture in Tropical Climates provide insight into this question:

> At a time when both local and expatriate agencies, and governments have--as never before--been seeking to increase agricultural capacities and labour-intensive activities in technologically-developing countries, beekeeping has become one of the most neglected areas for potential development...Under-exploitation seems to be the result of a number of factors, among which are the following:
>
> 1. Beekeeping does not seem to fit into any of the pre-existing categories recognized by those responsible to assessing development priorities. When agricultural or livestock

> potentials are studied, it is simply overlooked. Many people even seen to consider it too "grass-roots" to merit the attention of major development support, although it might be "fine" as a Peace Corps project, or the like.
>
> 2. Few, even in the USA, truly realize the importance of bees for crop pollination, honey, and other bee products (wax, etc), or the high economic loss where bees are not fully exploited.
>
> 3. There is a general fear of and disrespect for the bee, on account of its sting. For example, many Americans regard wasps or hornets (e.g. yellow jackets) as "bees," so that when a person is stung by a wasp, the bee is given credit--although it is rarely the culprit. The fact that the African bee _is_ more "aggressive" reinforces this prejudice.
>
> 4. At the present time, the real obstacle to the exploitation of bees is not lack of expatriate training personnel for beekeeping programmes, nor limitation of finance or supplies; it is lack of knowledge concerning the potential of apicultural programmes on the part of donor and/or implementing agencies.
>
> 5. Persons practicing traditional beekeeping in the tropics and sub-tropics mostly use inadequate methods for handling and marketing honey and wax, and therefore lack a profitable commercial market. (Swanson, 1976b, p.191).

Reviewing these comments, one may note that four out of five reasons for under-investment in apiculture are attributed to human attitudes, and general ignorance--certainly, a situation worthy of some reflection. The need for education on this subject extends worldwide, to persons active in many disciplines. Swanson's list is by no means all-inclusive, however; many other factors act as constraints on the economic potential beekeeping holds for poor individuals (as well as others) in low-income nations. Analysis of these constraints will likely provide insight into methods for dismantling the barriers to wide-scale development of apiculture.

PART II: CONSIDERATION OF DEVELOPMENTAL CONSTRAINTS

SECTION I: BIO-ENVIRONMENTAL FACTORS

A. The Biology of the Honeybee

In the words of Professor Friedrick Ruttner, an international authority on bee breeding, "A successful bee economy needs, in addition to good (nectar) flows and ambitious beekeepers, first of all a capable bee. Vigor and ability to develop the colony, gentleness and quietness on the combs, and the capability of gathering large amounts of stores are the qualities primarily required of the bee... One cannot expect from natural selection, the development of a race perfectly fulfilling the requirements of the modern beekeeper. But the comparison of the typical characteristics of the different races shows that one race approaches the ideal more closely than another one...In its original homeland...the honey bee remained under the effect of natural selection for a long time. Man's influence in the early days on its habitat was small and probably of local significance only...In the different regions, under the influence of selection by climate, flora, and enemies, adjusted types developed in the same manner as did other wild animals and plants. These types generally are known as natural or geographic races or sub-species. "Race" therefore has not the same meaning in bee breeding as in breeding of other animals. "Race" in the breeding of dogs, cattle, or chickens means a result of long, planned breeding. The *geographic* races of bees are the results of natural selection in their homeland: they became adjusted to their original environment, but not always to the economic requirements of beekeepers." (Ruttner, 1975, pp. 19,35).

Due to the proliferation of *Apis* in so many different environments, the large number of "races" or sub-species presently known is far too detailed for the purposes of this discussion. However, Dr. Ruttner's comments can be applied at the species level, for the purposes of examining the economic constraints imposed by the various species of bees themselves. (Only the African bee, *Apis mellifera adansonii*, will be examined at the sub-species level, due to its economic impact over a large portion of the world.) It must be made clear that, despite the best efforts of beekeepers, the economic potential of apiculture must always rest upon the ability to understand and successfully manage a creature whose behavior still holds many mysteries, for even the keenest scientists.

Apis mellifera presently occupies a large geographical area which includes tropical, sub-tropical, and temperate zones. It is indigenous to Africa, parts of the Middle East, and Europe; within these areas, many different races established themselves. Those indigenous to temperate zones in Europe, (which will be referred to here as the "European bee"), were taken to northeastern North America in the early 1600's, and eventually spread through most of the continent, and into both Central and South America, over a period of several hundred years. (Crane, 1979, p.1). Then, in 1822 it was taken to Australia, and into New Zealand in 1842. (Crane, 1975c, p.412). All of these New World areas were formerly without indigenous species of _Apis_, and before their introduction, the native inhabitants procured their honey from "stingless bees," belonging to the two main genera _Trigona_ and _Melipona_. Due to the wide area populated by _Apis mellifera_, equally-wide variation exists among its different races and strains. But, general characteristics of this species can be described. It builds a multiple-comb nest, and requires darkness to do so, making it a good hive bee. This factor is important in making it possible to move colonies into crop pollination, where desirable. _Apis mellifera_ is capable of building up a strong population, to take advantage of large nectar flows; furthermore, it will forage within an approximate area of 3000 meters from the hive (about 1.86 miles), or slightly farther if necessary. (p. 415). Currently, most of the world's honey production is the result of the successful management of this bee. Distinctive differences may be noted between the behavior of the European bee, and that of _Apis mellifera adansonii_, the African bee. The European bee is much gentler and thus easier to handle, is not as prone to regular swarming and absconding, and is able to overwinter quite effectively if it has sufficient stores of honey. On the other hand, the African bee is markedly more defenseful of its colony, is prone to frequent swarming and absconding, and is not capable of withstanding freezing temperatures for a prolonged period. It is, however, an outstanding wax-producer; and this fact has greatly enhanced its economic value. It is also known to forage earlier in the morning and later in the evening than the European bee tends to, and is again an outstanding honey-producer. As mentioned in the Introduction, African bees were accidentally introduced into Brazil in 1956, thereafter spreading across much of the South American continent. Although their agressive nature initially caused many management problems, for commercial beekeepers in particular, reports confirm that today these "Africanized bees" have caused production levels to soar, for both honey and beeswax. Changes in management strategies include smaller beeyards; methods for restraining the bees' swarming impulse; working the bees late in the afternoon or early in the evening, so as to let them calm down again before morning; the wearing of more protective clothing; the use of a more-efficient type of smoker; and the provision of greater space (approximately 2 meters at minimum) between colonies, to reduce the disturbance to others while one is being worked. Considering all races which make up the species Apis mellifera, then, one may accurately say that it is presently of the highest economic value--and possesses great potential for further development, particularly in regard to progress made with both the African and "Africanized" bees, in dealing with the constraints imposed by incomplete understanding of the behavior these latter two exhibit. Since pollination has been shown to be one of the most important of potential contributions, methods for moving these defenseful bees into agricultural areas for pollination services will need to be developed; and, as many types of traditional hives are not readily transported, improvement in hive designs remains an additional limiting factor.

Apis cerana is indigenous to southern and eastern Asia, and is presently found in that region's tropical and sub-tropical areas, as well as in the colder regions of Siberia, northern China, and the higher altitudes of mountains in central Asia. *Apis cerana* is quite similar to the European bee, *Apis mellifera*, in that it also builds a multiple-comb nest, preferring caves or hollow trees for nesting sites. Aside from morphological differences, behavioral contrasts are also apparent. When the hive is disturbed, it exhibits body-shaking and makes a hissing noise, in addition to stinging behavior. (Koeniger, 1976, p.48). In contrast to the defenseful nature of the African and Africanized bees, *A. cerana* is known to be quite gentle, and is thus easy to handle in this respect.

Particular problems arise for the beekeeper in that it swarms and absconds frequently, making it difficult to project production levels over a given period. Absconding may be closely tied to its foraging behavior; Crane cites sources which estimate that *Apis cerana* commonly forages only within a 700 meter distance from its hive, or slightly more. (Crane, 1975c, p.415). When and where nectar and pollen become short in supply within this general range, absconding may be the common response. Koeniger reports that particularly with tropical races of *A. cerana*, once the population reaches 20,000 or so, the colony will have the tendency to swarm, and may issue perhaps as many as eight successions of small swarms, some of which may contain only 200 bees. (Koeniger, 1976, p.48). He reports that some breeding programs are appearing successful in reducing the frequency of this activity; but, as swarming and absconding are useful and integral aspects of colony survival, particularly in tropical environments, this too must be taken into account. In addition to smaller populations within a colony, *Apis cerana* builds a smaller wax comb, and produces less honey per year (on average) that does *A. mellifera*. Honey production tends to approach an average of 20 kilograms per year in the more temperate regions, but only about 5 kilograms per year in the more tropical areas. Due to the limited colony buildup described, little wax is produced, thus far making it doubtful that *Apis cerana* could be of much value in this respect. Careful colony management has resulted in good honey yields in India, China, and northern Pakistan; and hopefully, progress with this species will be forthcoming in areas now intensely developing their apiculture programs. Attempts have been made in the past to import Apis mellifera, but with little success, as the foreign bee fell prey to predators, diseases, and generally failed to compete with the local bees. Another constraint to be faced in regions working with Apis cerana is the quality of the honey produced. Crane reports findings that some honeys have a high water content, varying from 16.6% to 26.4% in Mallik's studies; (Crane, 1975c, p.415) while she quotes Vorwohl as finding not only higher water content, but lower levels of diastase, which is considered an indicator of honey's quality and authenticity. (p.418). In tropical areas, high water content can cause problems with fermentation of honey, greatly lowering its marketable value. Thus, regions hoping to take advantage of Apis cerana's potential, which is considerable, will also have to deal with the problems which have been described.

Apis florea, sometimes called the "dwarf honeybee" due to its distinction as the smallest species of Apis, is native to many regions in Asia, the Middle East, and some Pacific areas such as the Phillipines. Found mostly in feral (wild) colonies, it builds a small, single-comb nest in the open, making it exceedingly difficult to manage in beehives. The only dwelling which approximates a hive is that of a cave; some colonies suspend their comb from the roofs of caves, which protect the nest from harsher climatic elements. Koeniger reports Tirgari's findings, that in hotter regions Apis florea will often choose to build comb on the underside of a tree branch, to protect itself from the sun's rays. (Koeniger, 1976, p.48). To establish ownership over feral colonies, and permit their protection, persons working with this species have attempted to create suitable environments for them, in an alternate type of apiary--that is, by the construction of artificial "caves," or by transferring the feral colonies to a similarly-desirable tree branch. Some success with these methods has been described by Dutton and Free, working with the Khabura Development Project in the Sultanate of Oman. (Dutton and Free, 1979). They discuss the difficulty of maintaining established colonies in one location, as Apis florea tends to abscond readily, whenever forage conditions become unfavorable. This fact is possibly related to the observation that this species tends to forage within 400 meters of its hive; (Crane, 1975c, p.415) such a limited range, comparatively speaking, would make absconding urges an important survival characteristic, particularly in arid regions with limited floral sources. Generally speaking, a lack of knowledge concerning the behavior of Apis florea, resulting in many cases of unsuccessful management of these colonies, is a major constraint. For this species to be of significant economic value, a higher success rate must be obtained, since the size of the honeycomb yielded at each harvest may amount to only 2 or 3 kilograms, (Dutton and Free, 1979, p. 185), and very little wax. This is not to discount, however, the significant role *Apis florea* plays, as a plant pollinator.

Apis dorsata, often termed the "giant bee" or "rock bee," is the largest of all *Apis* species, and is native to the same general areas inhabited by the tropical and sub-tropical races of *A. cerana* and *A. florea*. Although this species has not been "domesticated" to any great extent, and is reported to be extremely fierce in defense of its nest, it is an important bee to many regions of Asia and nearby islands, due to the large quantity of honey obtained in most hunting expeditions. Koeniger reports that one comb may yield as much as 50 kilograms of honey, depending upon the season and the size of the colony. (Koeniger, 1976, p.47). Smith appropriately describes *Apis dorsata* as "the most productive bee of tropical Asia," not only for its honey crop, but for its wax comb. (Smith, 1960, p.13). Called "Ghedda wax," it is described as having a wider range of properties than does beeswax from *Apis mellifera*, and is physically and chemically distinct from the later. (pp. 198-200). An active market exists for both these products, encouraging honey hunters to persist in their search for this species, often in densely-forested tropical areas. Once a colony has been located, however, gathering the crop is not an easy task. Often, *Apis dorsata* will nest quite high in trees, and it is therefore necessary to climb to precarious heights a good portion of the time; then, the bees themselves must be dealt with--colonies may number as many as 60,000 to 80,000 workers, who are roughly the size of the *Apis mellifera* queens, and who are notorious for their ferocity. Various aspects of this species' behavior, then, are primary constraints to its economic development, although the natural contribution it makes as a plant pollinator is hardly obscured by its behavioral difficulties. Some advances in designing a suitable hive for this bee have apparently been made, but not yet put into use over a wide area. Progress in this vein is clearly important, and deserves continued effort. Also a problem is the high moisture content of much *A. dorsata* honey, the humid tropical regions of much of its domain being a large contributing factor in this regard. Perti & Pandey researched this topic, and report that samples taken in Nainital, India, contained about 17% water during the summer months, and 26% water in the rainy season. (Perti and Pandey, 1967). Fermentation becomes a problem whenever the moisture content exceeds 17.1%, according to one author, and is particularly likely above 20%. (White, 1975, p.238). Means to solve this problem are available, but require technological involvement, which may not be feasible in remote regions. Some local markets for fermented honey do exist; but if eventual wide-scale production for export is the target, problems of this nature must be solved.

Dissatisfaction with the native bees' characteristics has, in past times, caused many experts to prefer the importation of a "foreign" bee, deemed more desirable. In many cases, Apis mellifera has filled this role--but not well. Particularly in tropical environments, it has been unable to compete with the native species; and, most apiculturists today strongly advise against importation of non-native species, as a method for dealing with the behavioral constraints imposed by native honeybees. Professor F. Ruttner comments in this regard:

> Many workers have felt the need to diminish the undesirable traits of...bees by importation or by selection...Of course first of all, the basis of any programme of this kind must be built up: a skillful modern apiculture with trained technicians. The idea of procuring a "better bee" is not the first step of a development programme in apiculture, but the last one.
>
> Very cautious experimental work must precede any attempt to change the genetic composition of the local population of bees, and the easiest way--the importation of a foreign race--is probably in most cases the one least to be recommended. On the other hand, the local bee will be adapted to the local environment in an almost perfect way. But it will have traits undesirable for modern beekeeping, and natural selection will continue to favour these traits: aggressiveness (the more, the better the chance to survive), absconding, swarming. Thus, a selection has to be started to change the bee in the opposite direction, towards gentleness, steadiness, non-swarming. It has been shown in the temperate zone that remarkable success may be achieved, but in the tropics the conditions are more difficult. In most places, a large wild population

> is likely to exist. Thus, changing the controlled population mainly by changing the drone population--which can be done very quickly--is not feasible. But with the technique of artificial insemination, which by now is ready to be applied on a large scale, a programme may be developed to overcome this difficulty. The bees of the tropics should now enter in a stage of intensive study, and only in a later period can plans to "improve the bee" be started. The consideration of the biological facts, keeping in mind certain recent experiences, could prevent many mistakes and fiascos. (Ruttner, 1976, p.45).

Thus, the developmental constraints which the various species of Apis impose upon efforts to improve beekeeping are substantial, but impermanent. As knowledge of honeybees' behavior accumulates, barriers to further development are removed. To this end, the observations of individual beekeepers are of the utmost importance, in guiding scientists in this field to areas which require special scrutiny.

B. Agro-Climatic Factors

The physical and behavioral characteristics of honeybee species, just discussed, have evolved in accord with the bees' micro-environment, largely shaped by the physical geography and climatic conditions of a given region. Climate has thus been a decisive factor in determining not only the plant life available to honeybees, but also in shaping their foraging instincts. F.G. Smith discusses this subject at some length, and it is largely his text which will be followed here. (Smith, 1960).

Honeybees' foraging instincts are markedly influenced by the length of dearth periods in the course of a year. Where the average winter temperature falls below 57°F. (14°C), the colony must form a ball-like cluster to maintain enough warmth to survive. During such periods, stored honey is consumed to generate the energy required for this purpose. Thus, bees inhabiting such zones instinctively forage for as much nectar and pollen as they can, storing these substances away for use during the colder season. In the tropics, similar dearth periods may be effected during long periods of heavy rain, or a lengthy dry season. If collected reserves are not sufficient to outlast such circumstances, the colony will not survive. On the other hand, bees populating areas which experience no extended dearth periods have not developed the same foraging and storing instincts as those just described. Rather, they need only reserve sufficient food to outlast short rainy periods, when flight activities cease. If and when a shortage problem arises, the colony will readily abscond to a more suitable location nearby. From the beekeeper's point of view, it is the intensive foraging and storing instinct which is most desirable for maximum honey and wax production; and thus, beekeepers in tropical areas with very brief dearth periods are constrained by the bees' lack of initiative in this sense. Selective breeding of queens which produce colonies with the desired traits is an effective method for dealing with this situation.

Temperature has been recognized as an important factor in the frequency with which honeybees swarm. Swarming is the method by with the colony reproduces itself, through the development of a new queen bee in the hive, which will eventually mate and return to the colony which she came from, and thereafter begin her egg-laying duties. While this new queen is being developed, the worker bees "dry up" the queen (prevent her from laying eggs), as a means of preparing her for flight. Commonly, just before the new queen emerges from her cell, the old queen will fly away from the hive, accompanied by perhaps half of the original colony. This swarm will usually land in a nearby site, while scouts look for a new home. The location decided upon will be communicated to the colony through a particular "dancing" pattern, and the swarm will then take up residence there, and begin the job of building and expanding the colony. In colder climates, swarming is generally limited to the late spring and early summer months, due to the fact that newly-issued swarms must store sufficient reserves, and build up the hive population to the extent that they can survive the winter's weather. On the other hand, honeybees in tropical regions are not restricted by such needs, and are therefore capable of issuing smaller swarms, on a more frequent, year-round basis. Management of this swarming instinct is extremely important, as uncontrolled swarming from one's apiary results in loss of valuable foraging potential, and an ensuing drop in honey and wax production, as well as diminished pollination potential. The economic loss inherent through failure to manage both swarming and absconding should, at this point, be well understood.

Temperature is also influential in determining the efficacy of the rainfall a given region receives, which in turn is a determinant of the vegetative growth possibilities. At higher temperatures, a larger portion of total rainfall is lost through evaporation, and thus made unavailable for plant growth. Rainfall and humidity levels also affect nectar secretion in plants. Smith says in this regard, "In the deciduous woodlands, adequate rainfall in one year results in good crops the following year. Some species of trees flower on the day following heavy rain. Moist warm conditions with some cloud cover tend to result in good honey-flows, while hot dry winds can be disastrous. Whereas the flowering of many trees varies according to the rains of the previous year, herbs, unable to store much reserves of starch, are responsive to current rainfall." (Smith, 1960, p.67). In an article entitled, "The Ecology of Honey Production in Sri Lanka," E.F.W. Fernando reports:

> Meterological conditions have been shown to be a major factor influencing plant growth, flowering periodicity, and availability of pollen and nectar. They also influence the flight activity

> of honeybees. Butler (1941), Synge (1947), and Percival (1950, 1955) have shown that the pollen gathering behavior of Apis mellifera is influenced by the time of day at which pollen is available, while Wafa and Ibrahim (1950) found that such activities were also correlated with temperature. Bight and Pant (1968) have shown that in Delhi, India, there is a negative correlation between temperature and pollen gathering activity, and a positive correlation with relative humidity for A. cerana. Jay (1973) has reported that in Jamaica, A. mellifera visits mainly male coconut flowers in the morning, but gathers nectar from both male and female flowers in the afternoon. (Fernando, 1979, p.115).

Smith relates additional information on plant responses to climatic variables, saying:

> Another effect, possibly due to low humidity, is that the secretion of nectar by many honey plants, particularly in dry areas, starts in the cool of the evening. It apparently goes on through the night and ceases when the day begins to get hot again. During the heat of the day, not so many plants secrete nectar attractive to honeybees. From 5 p.m. until dark, the bees collect nectar in moderate quantities, but at first light in the morning the air is filled with the roar of bees working in flowers. This may continue until 8 a.m. (Smith, 1960, p.67).

Smith also notes the importance of topography on plant growth, especially in cases where it restricts drainage, or increases the area's cloud cover. Additionally, edaphic factors are also recognized as one determinant of plants' flowering activity and nectar production. In other words, different soil types can produce different qualities of honey, even from the same plant species.

Eva Crane has related honey yields per hive to latitudinal corrdinates: "At low latitudes, the high temperatures allow the bees to fly and forage all the year round, instead of 6-8 months only; at high latitudes, the long hours of summer daylight allow the bees to fly and forage for, say, 20 hours out of 24, instead of 12 hours only; if the main honey crop occurs near midsummer, it can give higher yields than at lower latitudes...(for example) northern Sweden, northern Alberta in Canada." (Crane, 1965, p.306).

Altitude may also affect plant growth cycles, flowering phenology, nectar secretion, and so on. Higher diurnal variation present at higher altidues is a key factor in plant response to its location. Commonly, as one moves to higher and higher altitudes, a limit is reached, beyond which the forage available to the colony is insufficient to sustain a healthy population. Therefore, altitude may present considerable limitations on beekeeping potential, in some cases.

A final comment by Crane reiterates some of the points touched upon earlier: "Neither the plant honey potential nor the bees' foraging potential can be realized in poor weather. No bees fly to collect nectar if the temperature is less than 12°C. (53°F.) or so. Plants cannot yield nectar unless the temperature is high enough...Rain or high humidity can make nectar more dilute and give the bees much extra work, both in carrying the nectar home and in evaporating off the excess water. Few bees will fly in a wind of more than 25 km. (15 miles) an hour. Apart from damage by diseases and pests, and catastrophes such as fire, weather is the main factor underlying year-to-year variations in nectar flows from the same plant species." (Crane, 1975d, pp.14,17).

The preceding discussion sketches for the reader some of the fundamental constraints which agro-climatic factors pose for honeybee management. In this regard, one should recognize the fact that many of the factors discussed are generally beyond the control of the beekeeper--rather, they are variables to which s/he must adapt his/her management strategies appropriately. In some cases, intervention may be feasible via the purposeful planting of honeybee forage, to reduce the length of dearth periods, and improve the quantity and quality of nectar and pollen available to the hive. Plantings which improve soil conditions concurrently, such as those which are nitrogen-fixing, are even more advantageous than those which do not possess such properties. The integration of appropriate honey plants, optimally suited to the agro-climatic conditions which exist in a given region, offers a means of dealing with this particular sort of bio-environmental constraint on apicultural development.

C. Diseases, Pests, and Predators

As is the case with all living organisms, honeybees are the natural target for numerous attacks by diseases, pests, and predators. In the wild, colonies severely affected with disease are likely to succumb, without human interference;

similarly, a percentage will be successfully overrun or destroyed by pest attacks or insect-eating predators. Where bee colonies have been collected to form an apiary, though, a vital function of the beekeeper is the safeguarding of these colonies from such hazards. A detailed discussion of the individual diseases and pest problems affecting honeybees is so lengthy that it is best left to other authors who have dealt with each of them specifically; therefore, this work will only summarize the production constraints imposed by these threats to the honeybee colony, and offer recommendations as to what can be done to override them.

Honeybee diseases may be classified into at least 4 basic categories: 1) bacterial; 2) viral; 3) protozoan; 4) fungal. Most diseases attack the immature bee (that is, the larval or pupal stages), with adult diseases being somewhat less common. American foulbrood (AFB) and European foulbrood (EFB) are two widespread bacterial diseases which attack the larval stage; a condition known as sacbrood is a virus-induced larval disease; and the fungus *Ascosphaera apis* has been identified as the causal agent of a larval disease called chalk brood. These diseases, and others which similarly attack honeybee larvae, interfere with the bee's productive potential by reducing the total number of bees which reach adulthood. The colony then suffers from an insufficient number of workers to carry out necessary functions, notably nursing other larvae and foraging for

for pollen and nectar. As the hive population dwindles below normal levels, so does the chance for extended survival. If bees are being used in agricultural pollination, a lack of "field force" understandably reduces the percentage of plants effectively pollinated. Diseases which plague adult bees, such as the protozoan-induced nosema disease, lead to shrinking hive populations as well, and a corresponding reduction in both production and pollination. Surviving adults may be weak, undersized, physiologically impaired, and thus of reduced longevity. All of these factors, or any combination thereof, can effectively cripple a beekeeping operation, and thereby reduce economic gains which would otherwise accrue to the manager.

The same is true for life-threatening pest problems affecting honeybees. A number of parasitic mites have been identified as significant threats to beekeeping, and are the subject of intense research aimed at biological control of the problem. The microscopic mite, *Acarapis woodi*, invades the tracheal system of the adult bee and multiplies there, causing the death of its host. Two external mites, *Varroa jacobsoni* and *Tropilaelaps clareae*, were first discovered in southeast Asia, but are no longer restricted to that region alone. The *Varroa* mite is commonly found on the backs of young drones and workers, and if unchecked, may multiply to the extent that the colony ceases to be productive. *T. clareae* will feed on either living or dead larvae, pupae, or adult bees, causing a similar damaging result. In some cases, the two mites may simultaneously infect a single colony, compounding the destructive effect of their presence.

Another common pest within the hive is the wax moth, Galleria mellonella L., which lays eggs in the waxen comb of honeybees; as wax moth larvae develop, they burrow into the wax, feed on pollen, honey, and pupal skins, and weave silken tunnels throughout the comb. These webs may become so extensive in weak colonies that brood sealed in cells is unable to emerge properly, and large quantities of valuable beeswax is rendered unmarketable. Damage by the wax moth can thus range from slight to severe, to some extent depending upon the strength of the bee colony and intervention on the part of the beekeeper.

Other moths have been identified which do not breed within the honeybee colony as Galleria does, but which instead rob from the nest. Smith terms the most notable of these the death's-head hawk moth, Acherontia atropos in Africa, Acherontia styx in India, and Acherontia sp. in Indo-China. (Smith, 1960, p.55). He states that strong colonies usually destroy these invaders, and throw them out of the hive in small pieces. But in weaker colonies, where sections of comb may be unguarded, these robber moths may prevail.

Similarly, there are two distinct types of beetles which create problems for the hive--those which come to steal from the colony, and those which desire to breed within it. The former type, encompassing a wide variety of genera and species, can best be handled by strong colonies which possess sufficient numbers of guard bees to patrol all combs; or, as Smith suggests, by reducing the entrance to the hive, to restrain the larger forms of beetles, and permit the guard bees at the entrance to defend the hive more successfully. (Smith, 1960, pp.54-55). *Aethina tumida* is representative of the latter type described, as it breeds within the colony itself. Commonly known as the small hive beetle, its adult size averages about three-sixteenths of an inch long; this fact, along with its quickness and ability to hide in cracks and crevices, makes it difficult for the bees to catch. As beetle larvae develop, they feed on both pollen and honey; they destroy the pollen combs entirely, leaving only a pile of dust, and cause the honey they have fed on to ferment and run out of the comb. They have been termed the most serious beetle pest in Africa. (Smith, 1960, p.55).

The so-called bee louse, *Braula caeca*, which in fact is a sort of wingless fly, is another widely-distributed bee pest. Adults have often been observed on the bodies of queen bees, but less often on either workers or drones. These adults are said to do little damage, as they mainly steal just a small amount of food from the host's mouth-parts. But the larval stage of *Braula* is quite different; it will burrow into capped honeycomb, and thereby render some of it unmarketable.

In many parts of the world, the threat of any attacks on bee colonies is one of the beekeeper's primary considerations in apiary design. Although many different species of ants are known to pose this danger, it is the safari ants which are perhaps best known for their ability to attack and overwhelm an entire bee-yard overnight. Beekeepers must thereby combat their presence by making all hive stands absolutely ant-proof. Smith describes several such precautions, such as wrapping each leg of the hive stand with cloth soaked in corrosive sublimate, a dangerous poison; the spreading of fresh wood ash on the ground surrounding the hives; standing the leg of each hive in a can full of oil; or, the smearing of banding grease on the legs of all hives. (Smith, 1960, p.57). He correctly notes that if ant attacks become frequent, troubled colonies are certain to abscond with little hesitation.

Wasps are another of the honeybee's predators, and can create some serious problems for the foraging population in particular. In parts of Asia and the Near East, various species of the genus *Vespa* are described as serious predators on honeybees; while members of the genus *Palarus* and *Philanthus* have likewise been identified in both Africa and parts of

Asia. (Smith, 1960, p.56). _Palarus_ is likely to be found near the hive, where it will wait for passing foragers, sting them, and take the bee to its nest, to be used as food for the larvae. _Philanthus_, on the other hand, is said to capture most of its prey while the bee is visiting a flower site.

Where hives are located near the ground's surface, frogs, toads, and lizards may become a problem, as their interference with the colony may cause the bees to become irritable. Moving hives onto stands, or suspending them in some manner, may alleviate much of this problem.

Birds are particularly difficult predators to deter, but fortunately they do not pose as serious a threat to the colony as do many other creatures previously described. Most birds catch and eat flying bees, although some alight on or near the hive itself, make a tapping sound with their beak near the entrance, and then capture the guard bees which emerge to defend the colony. Perhaps most notable among birds is _Indicator indicator_, commonly known as the greater honey-guide, which will gradually lead humans and small animals called ratels to feral honeybee colonies, in the hope of reaping a portion of the harvest. The honey-guide usually waits until the honeycomb has been taken from the colony, and then swoops down to eat the remaining comb. Smith reports that this species has been found to possess the ability to digest beeswax. (Smith, 1960, p.54). It is most commonly found in parts of southeast

Asia, the Himalayas, and in Africa south of the Sahara desert. The ratel, also known as the honey badger, or *Mellivora capensis*, is described in the following manner:

> The honey badger...is a powerful animal about three feet long, with a very tough skin and wicked claws...This animal breaks up beehives and steals all the comb without being worried by stings. It is very dangerous at close quarters, and if you come across it, get out of its way unless you can put a rifle bullet into it. It knows no fear, attacks with a hissing snarl, has very powerful legs armed with long claws, and it goes for the tenderest parts. It can push hives off stands and smash up timber seven-eighths of an inch thick. It may be followed in its depredations by the giant white-tailed mongoose, and the civet cat, which, like jackals after a lion, eat up whatever the ratel leaves...The honey badger seems to be distributed throughout tropical Africa, south of the Sahara. In Java, the yellow-throated marten, *Charronia flavigula robinsoni*, also of the family Mustelidae, attacks hives in a similar manner. (Smith, 1960, p.53).

Similar widespread damage may be caused by bears, which inhabit North America, and will invade an apiary in hopes of feeding on the honeybee brood. In these areas, beekeepers are finding that little else but electrified fences can effectively deter these predators.

Skunks may also present a problem, as they enjoy eating honeybees, and seemingly are not dissuaded by the stings they inevitably receive in their mouths, when doing so. They are often found in the apiary at night, scratching at the hive entrance, and eating those bees which emerge to attack the enemy. This type of disturbance may irritate the colony a great deal--and it is usually the unsuspecting beekeeper who comes to tend them soon afterward, who receives the brunt of their displeasure. Placement of a robbing screen, made of fine wire mesh, over the hive entrance has been found to be an effective deterrant, as it forces the skunk to reach farther upward, thereby exposing its soft underbelly to the bees' stings. Reports suggest that skunks will often leave hives protected in this manner alone. (Gochnauer, Furgala, and Shimanuki, 1975, p.653).

Finally, hive equipment should be regularly checked for the presence of mice, as these rodents will often build their nests inside unoccupied honey supers, or will burrow into the lower portion of the hive during winter periods, after the cluster has moved farther upward in the hive. In so doing, they destroy valuable honeycombs, which could otherwise be used by the bees, or sold for their wax.

Having thus described only a representative portion of the many types of diseases, pests, and predators which may plague the honeybee colony in one manner or another, the reader should have begun to appreciate the economic threat which any or all of these problems may bring to the beekeeper. Several specialists in this field have offered the following comment:

> More options are becoming available to the beekeeper in protecting his bees from bacterial infections such as the foulbrood disease. Each option involves differing costs and effectiveness, depending on many factors of crop, climate, equipment, types of bees, and disease levels encountered. The final goal should be a disease-free unit in which one could freely transfer bees, equipment, and food stores without hindrance. Where bees are operated in a closed

> system with little introduction of foreign bees or equipment, or little travel outside their home territory, this may be feasible...
>
> The future may well see, as is occurring now in the harmful insect control field, a development of well-founded, rational systems of specialized management, combinations of natural and artificial control systems, and above all, a more sensitive and selective system of detection of diseases. This could be aided in part by development of a detailed, uniformly-tested manual of methods for detection and identification of dependable stock of bees for infectivity and other tests in the differing beekeeping regions of the world...
>
> The final test of any experiment or field trial in disease control is its effect in a commercial apiary. Few beekeepers can afford the specialized services of a veterinarian or other trained person to examine and treat if necessary, their livestock. In the end, disease control is a do-it-yourself project. The well-trained, properly-equipped beekeeper is well able to do it himself. (Gochnauer, Furgala, and Shimanuki, 1975, pp.653-654).

Of course, it is important to recognize the fact that not all beekeepers are well-trained, nor properly-equipped--particularly those who live in the world's low-income nations, where special training may be non-existent and extension assistance rather limited. But there still remain methods of management which have the potential to limit the damaging attacks of diseases, pests, and predators. Perhaps most importantly, beekeepers should strive to keep their colonies "strong"--that is, of reasonably high population levels, made possible by the presence of a healthy queen, who is laying large quantities of fertilized worker eggs. Smaller, weaker colonies should be united to form stronger ones, as long as the presence of disease in the weaker hives is not suspected. Secondly, beekeepers should strive to obtain as much accurate information as possible on the potential problems of this sort specific to his/her region, and then undertake regular self-inspection of all colonies. If irregularities are observed at any time, immediate treatment should be sought, to prevent the problem from spreading any further. In some cases, isolation of suspected hives from healthy ones may be a reasonable precaution to undertake; in other cases, infected colonies may have to be destroyed completely. The inherent economic risks which have been described are understandably lessened significantly through education of beekeepers as to proper methods of diagnosis and effective treatment.

D. Pesticides

Little has yet been said regarding one remaining, and significant, honeybee predator. In the words of F.G. Smith: "There is no doubt that the greatest enemy of the honeybee is Man. He destroys colonies wholesale by completely robbing them of all their food, as well as eating their brood. Even when he has advanced to frame hive beekeeping, he upsets the colony balance by unnecessary interference with the brood nest, taking too much honey, and spreading bee diseases. Added to that, he poisons the bees by spraying the flowers, their source of food, with insecticides." (Smith, 1960, p.53).

Indeed, many beekeepers would be inclined to agree that one of the most perplexing problems they face in modern times is the extensive mortality to their colonies, caused by chemical insecticides. Dr. E. Laurence Atkins, who has written at length on this subject, says of the situation:

> The demand for an increasing amount of food and fiber has necessitated enlarging the size of farm and ranch production units, utilizing more acres of land for growing crops and accelerating the mechanization of agriculture. The increased acreage in crops and the larger fields of a single crop favors the development of insect, mite, and disease problems. This in turn usually requires that more pesticide treatments be made. Agricultural chemicals or pesticides for specific purposes are utilized to alleviate the countless pests of plants. Therefore, individual problems are controlled with chemicals for specific uses such as acaricides, antibiotics, chemosterilants, defoliants, desiccants, fungicides, herbicides, insect growth regulators, insecticides, nematocides and plant growth regulators. Unfortunately, the honey bee is susceptible to many of the pesticides used in such an intensive pest control program. As a result, the honey bee is subjected to an intensive and continuous hazard of chemical poisoning that overshadows all other problems, including bee diseases. (Atkins, 1975, p.663).

Atkins explains that three distinct pesticide actions may cause the death of honeybees-- 1) direct contact, absorbed through the bee's integument; 2) poisoning within the stomach, in the process of feeding or cleaning activities; 3) by fumigation, as poisons are absorbed through the bee's respiratory system. He then describes the alternative modes of action which may take place, once the bee has come in contact with the poison:

> The pesticide may affect only the alimentary tract. The alimentary tract may be paralyzed or physically altered, making it impossible for the adult to nourish itself and hence to function normally. The abdomen is frequently distended. This mode of action results in the adult starving or desiccating, causing death. More commonly, however, the mode of action caused by the organic pesticides used today affects the nervous system in various ways so that the legs, wings, digestive tract, etc. will not function, and the adult is therefore unable to orientate itself to find food, to replenish food and water, or is unable to utilize food and water, and hence indirectly dies from starvation and desiccation. Bees which are without food will become weakened after 3 to 4 hours, and will succumb to starvation after 6 to 8 hours. (p.665).

Field bees are perhaps the most likely to come into contact with pesticides, in the process of collecting nectar and pollen from flowering plants to supply the colony with food. In many cases, these foragers will die before they are able to return to the hive, resulting in a sudden food shortage. To correct this deficiency, house bees may be forced into the field at the expense of the brood for which they were caring. If the house bees are also stricken while attempting to forage, the hive will become so unbalanced that its entire population will tend to die out within a short time.

Atkins then explains at length what occurs when foragers manage to bring contaminants back to the hive:

> Foraging bees which become incapacitated at the hive are usually removed from the hive without expelling their load of nectar. When foraging bees eject their load of food, the hive bees process every drop of nectar brought in, and thus are exposed to any toxic substance it may contain for a considerable period of

> time. Hive bees tend to retain the food in their honey stomachs when they become affected by a poison, and are removed from the hive by other bees. Guard bees also resist abnormal bees, or bees which return with offensive odors, and remove them from the hive. When poisons are applied near the hive, some bees may return to their hives with the poisons on their bodies and contaminate some of the house bees. This sometimes results in many dead bees collecting near the entrance, again removing the poisons from the hive.
>
> Foraging bees can also collect pollens contaminated with pesticides and carry them back to their hive. If bees are affected seriously when they return to their hives, they are usually removed from the hive without expelling their load of pollen. If contaminated pollen is deposited in the hive from foraging bees, the hive bees may be poisoned in the process of storing the pollen in the brood nest. When nurse bees elaborate such pollens into brood food, they may become poisoned before they have fed many larvae. Such bees usually die on the bottom board or in front of the hive. In a few instances, some of all of the larvae are also killed. Populations in hives may become so reduced that the colonies either die or are too small to pollinate blossoms adequately, or to gather surplus honey. (p.668).

In this manner, pesticide kills can virtually destroy the beekeeper's economic foundation, as well as seriously limit the yields of agricultural crops which depend upon honeybee pollination. This situation should in no way be taken lightly, as one reliable estimate places the annual value of this pollination service to world crops at "considerably more than 1000 million (British pounds), much higher than that of the honey produced from bees, which is perhaps 20-30 million." (Crane, 1979, p.11).

In addition to the lethal effects of various pesticides on honeybees, there is presently growing concern over the possibility of undesirable chemical resisdues being present in the hive's products. Atkins says in this regard:

> The behavior of honey bees prevents almost all contamination of honey and pollen. A few instances of pesticide contamination have been detected in nectar, honey, and pollen in the hive from normal commercial pesticide applicatins. More often, no detectible residues have been found, although dead bees, pollen, and bee brood collected simultaneously did occasionally have variable amounts of pesticides present. In those instances where pesticide contamination has been detected, the amounts found were considered too small to be of significance." (Atkins, 1975, p.668).

The physical properties of beeswax make it a substance which can readily absorb many volatile chemicals, and it may therefore also suffer contamination in areas of pesticide application. (Witherell, 1975, p.543).

The danger of pesticide contamination of honeybee products is further increased through the widespread use of recently-developed encapsulated insecticides. These small nylon capsules are approximately the size of pollen grains, and have become popular among growers because of their slow-release mode of action. One source is quoted as saying:

> New encapsulated insecticides are much more toxic to honeybees than any so far developed. Because of their size, the capsules are carried back to the colony, and there can remain poisonous for long periods. These insecticides are banned in some states. They should <u>never</u> be used if there is any chance bees might collect the capsules. Always consider using another formulation first. (Sanford, 1979, p.3).

As the absolute purity and natural character of honeybee products is perceived as one of the most significant factors in market demand, contamination of this sort in the course of "established" agricultural practice is viewed as both damaging and unacceptable to many involved in the beekeeping industry. Current and future litigation may serve to clarify the rights and responsibilities of all parties in this regard. What appears even more important is the development of cooperation between those who keep bees, and those who do not. In large part, the constraining mechanism at work here is the lack of appreciation for the honeybee itself, and its role in bountiful agriculture--juxtaposed rather oddly with the general appreciation for fresh honey, pure beeswax, and healthful bee pollen, as well as the desire for maximum yields at the point of harvest. Development of workable agricultural systems which seek natural biological controls for pest management operations, and which permit truly-integrated utilization of beneficial insects, would go far in creating a base for cooperative understanding between these two groups.

On the subject of protecting honeybees from current pesticide use, the following steps should be taken:

> 1) Use insecticides only when needed...It is always a good idea to check the field to be treated for populations of both harmful and beneficial insects. 2) Do not apply spray while crops are in bloom. 3) Apply when bees are not flying: Bees fly when the air temperature is above 55-60°F. and are most active from 8 a.m. to 5 p.m....(this can vary somewhat)...Evening application allows time for insecticides to decompose during the night.
> 4) Do not contaminate water: Bees require water to cool the hive and feed the brood.

> Never spray standing water or drain tank contents onto the ground, creating puddles. 5) Use less toxic compounds. 6) Use less toxic formulations...dusts are more hazardous than liquid formulations; emulsifiable concentrates have less killing power than wettable powders; ultra-low-volume formulations are usually more hazardous than other liquid formulations. 7) Eliminate attractive weeds: Prior to insecticide treatment, mow or otherwise control flowering weeds near orchards or fields where the material is to be applied. 8) Notify beekeepers (in the area)...Colonies can be moved or loosely covered with burlap or coarse cloth to confine the bees and yet allow them to cluster outside the hive under the cloth. Repeated sprinkling each hour with water prevents overheating. 9) Avoid air applications: Aircraft application of insecticide is less accurate than other methods and is more likely to contaminate non-target crops. Air currents can cause the chemical to drift much more than when applied in other ways. Always consider alternatives to aircraft application...(Sanford, 1979, pp.3-4)

In evaluating the feasibility of any beekeeping program, it is therefore advisable to become familiar with the level of pesticide use in the area, as well as the conditions under which it is being applied. Careful assessment of all these factors should help to provide a clearer picture of the economic risks associated with any beekeeping enterprise.

E. Poisonous Plants

Some plants have been found to contain toxic substances in their nectar or pollen, resulting in the death of honeybees which come into contact with these toxins. In other cases the bee itself may escape poisoning, while subsequent human consumption of honey from these particular plant sources may cause sickness and, in extreme cases, death.

Poisonous nectar is likely to present a threat mainly to adult honeybees, and then only when the offensive plant is in bloom, for at other times the bee is unattracted to the harmful source. On the other hand, toxic pollens may affect the entire hive, as they are likely to be fed to the bee brood, as well as consumed by adult bees. If such pollens are stored in the brood-combs, the toxic effect may surface long after the poisonous plant has ceased its blooming period.

Atkins cites numerous sources which document the deleterious effect of the following plants on honeybees: California buckeye (Aesculus californica); black nightshade (Solanum nigrum); death camas (Zygadenus venenosus); dodder (Cuscuta spp); summer titi or leatherwood (Cyrilla racemiflora); locoweeds (Astragalus spp.); mountain laurel (Kamia latifolia); seaside arrowgrass (Triglochin maritima); whorled milkweed (Asclepias subverticillata); western false hellebore (Veratrum album); henbane (Hyoscyamus niger); horse chestnut (Aesculus hippocastanum); and rhododendron (Rhododendron spp.). (Atkins, 1975, pp.691-692). In cases where honeybees survive an encounter with these plants, problems such as deformity, queen supercedure, and the inability of queens to lay fertilized worker eggs may result.

On the subject of honeys toxic to humans, Atkins emphasizes the effects of honey from rhododendron, azalea, mountain laurel, the Australian tree "tutu", and jessamine.

Other reports implicate plant sources such as nightshade (Atropa); Egyptian henbane (Datura metel); yellow jessamine (Gelsemium sempervirens); Coriaria arborea, from which a honeydew on the leaf surface containing the toxin tutin can be obtained; and a great number of species belonging to the family Ericaceae (which includes Rhododendron, Azalea, Andromeda, Kalmia spp.) (Maurizio, 1975, p.96) (White, 1975, pp.202-204).

The economic constraints imposed upon beekeeping by the presence of poisonous plants may be hypothesized to range from nearly insignificant to severe, depending upon the botanical features of the region in question. Options such as the monitoring of honey, disposal of tainted products, and the possible eradication of toxic plant species in beekeeping areas--all these introduce cost elements, in both time and money, which must then be evaluated in light of expected benefits. In some cases, beekeeping may be deemed totally unfeasible. Dr. Gordon Townsend, speaking to a 1981 conference of the International Agency for Apiculture Development, described such a situation as existing in Nepal; although there is substantial interest there in developing a beekeeping industry, the abundance of rhododendron throughout the nation presents severe barriers to doing so. In Townsend's opinion, this particular problem must be solved before any real progress toward apicultural development can be made. (Townsend, 1981b).

The case of Nepal, in light of Dr. Townsend's statement, affirms the need for a careful survey of melliferous plants--including those which may produce a toxic effect--in a feasibility study, to precede any apiculture project. In this way, the limitations which poisonous plants present to a given area may be clearly evaluated in light of collected evidence, reducing the chance of costly, mistaken ventures. Where the data suggests that only honey may be adversely affected, a decision may be made to promote beekeeping for pollination and wax production, if the benefits from these activities seem warranted. But where evidence indicates that the bees themselves are likely to be harmed by indigenous plants, obstacles to apicultural development may be deemed insurmountable, unless action is taken to remedy the existing situation.

SECTION II: METHODOLOGICAL FACTORS

A. Knowledge of the Sociology of Apiculture

Developmental objectives in apiculture may be achieved through a seemingly unlimited variety of methods--but certainly, those approaches which consider as many of the social and cultural dimensions of the area as possible stand a much better chance of success than those methods which ignore these important aspects, or assign to them a nearly insignificant role in project design. Correspondingly, a lack of knowledge of the sociological features of bee hunting and beekeeping will act as a constraining mechanism of unpredictable proportion, and may contribute to outright failure, or in other situations to insufficient institutionalization of project concepts and goals.

Richard A. Swanson, a development anthropologist who has worked extensively with beekeeping peoples and projects in West Africa, is in hearty agreement with the concept just advanced. He is quoted as saying:

> We have reviewed some of the theoretical benefits of beekeeping...and some supposed reasons for its potential success. It is necessary to point out that, given an ideal environment, equipment, and good mechanical planning, the project will almost certainly meet failure unless local capacities and constraints for such a programme are known or anticipated and taken into account...Many beekeeping programmes have been successfully initiated, but have simply faded away in a few years. The cultural reasons for such failures...are often the most important ones.
>
> ...Theoretical benefits are rarely attained in full, and often the impact of a particular project on the rural poor is marginal. The reason

> for this is frequently the lack of relevant sociological data. An anthropologist should participate in the feasibility study of any development programme under consideration. Development anthropologists and sociologists are trained to identify both the mechanisms by which theoretical benefits become translated into effective advantages for the local population, and the constraints which will optimize the development potential of the project.
>
> Substantial and effective improvement in the material well-being of any group of peoples presupposes that their own perceived needs and desires (as well as means of attaining them) are taken into consideration. Introduction of new or improved methods of beekeeping, by definition, implies change in old ways of doing things, change in ways of thinking. One must never underestimate the knowledge of a given people about bees and beekeeping. Much can be done with existing traditional practices. Change can be directed from within indigenous concepts and perceptions, if the effort is made to learn of them. (Swanson, 1976b, pp.192-193).

Swanson goes on to address the more practical concerns at the implementation stage, estimating that a trained anthropologist/sociologist could learn a considerable amount about apicultural practices in a three to five week period. This information could then be utilized during the project's early stages, and continually updated as more knowledge is accumulated. He provides examples of the sort of questions which should be asked in such an investigation:

> 1) What social groupings are capable of responding most effectively in corporate groupings to the project (for credit extension, equipment responsibility, co-operatives, etc.)?
> 2) What are the indigenous uses of honey and wax (e.g. beer making, religious ceremonies)? Can side markets be developed for the wax (e.g. export, lost-wax casting, batik making) and for supplying beekeeping equipment?

> 3) Who are the local beekeepers? Do they represent a special class or clan within an ethnic group? What do they know about bees, honey, wax, floral sources, etc.? How many hives do they keep? When and how do they remove their honey? How do they market it? How much do they currently receive for its sale? What honey do they consider the best and why? From what and how are their hives constructed? Is special ritual involved? To whom do the hives go upon the death of the beekeeper (are they sold, given to the oldest son)?
> 4) Is there a difference in standard of living between a successful traditional beekeeper and his non-beekeeping neighbor (based on their own measurement of wealth)?
> 5) What would traditional beekeepers think of newcomers to the trade? Would there be problems? What would their potential be for co-operation?
> 6) What are the social consequences of increased availability of honey?
> 7) How will people respond to a new beekeeping opportunity, and should only local traditional beekeepers be aided at first? Will they assume the risks involved in shifting from working almost exclusively for household consumption and immediate markets to production oriented to consumers at some distance?
> 8) How can existing traditional beekeeping practices be modified to make them more productive and competitive in an urban market?
> 9) Would new and sustainable employment opportunities in fact develop, either directly or indirectly, as a result of beekeeping interventions? Would the quality of life be upgraded? (Swanson, 1976b, pp.193-194).

Answers to questions such as these can provide an important foundation for appropriate choices in the planning and design of program components, which should implicitly include the active participation of local people (beekeepers and bee hunters) in all stages of the development process.

Swanson then summarizes the implications of his proposed approach:

> It seems reasonable to state that any society has its own conception of a self-motivated, successful person, and of culturally appropriate means whereby such motivation and success may be channeled to the benefit of society... If we, as those seeking to introduce or employ improved beekeeping technology, do not know enough about a particular cultural or environmental situation to have confidence about the high rate of its success, then perhaps we should not expect the people to risk their very livelihood on such a gamble...Our task is to find the means of successful translation of our knowledge into feasible methodology for the people concerned--methodology, that is, which grows out of the cultural understandings of the people themselves, and is not solely an importation... Intelligent, reasonable investigation and recommendations will lead to successful interaction between expatriates and nationals in the country concerned. (p.197).

Utilization of the suggestions presented here could conceivably bring about a more positive situation--seen as that in which one's knowledge of beekeeping and bee hunting practices is no longer operating as a constraint, but rather is a vital tool in the building of greater social and economic well-being.

B. Beekeeping Technology/Hive Design

Examination of the literature on this subject reveals a great deal regarding historical progress in understanding and thereby managing bees to suit man's own purposes. Indeed, it does not take long to appreciate the fascination with which hive experiments were tried, and inventive devices created. But the emphasis here shall be placed on the development of suitable methodology for approaching the question of what kinds of equipment are most appropriate to any given area. In the final tally, two parties must be satisfied with the choice which is made: the honeybees themselves, and the beekeeper.

Dr. Eva Crane says in this regard, "The hive a beekeeper uses is the outward and visible expression of his capability for managing bees for his own purposes." (Crane, 1977, p.183). The emphasis here is upon the ingenuity of the beekeeper, for the bees themselves will readily accept quite a wide variety of dwelling-places, as long as certain criteria are met. Crane explains these requirements:

> The requirements of bees and of beekeepers are different, because what constitutes success for them is different. Success for a colony of bees is survival, coupled with reproduction (sending out swarms that themselves survive). Success for a beekeeper is most commonly a satisfactory return on his investment of money and time, and this is most likely to be achieved if the colony of bees stores honey greatly in excess of its own requirements, in a part of the hive from which the beekeeper can easily remove it. Usually this excess honey is produced at the expense of suppressing or diverting the bees' natural reproduction, that is, by using a system of swarm control...
>
> Fundamentally, there is only one measurement that must be adhered to precisely in hive design, to conform with the bees' requirements. This is the distance between adjacent combs (centre to centre) in the brood space. All other measurements either lie within fairly wide limits of tolerance for the bees, or are chosen to suit the beekeeper, not the bees... Both the distance between combs and the cell diameter differ somewhat between different races of bees, and between the two species

of hive bee, *Apis mellifera* and *Apis cerana*. (In the other two species of *Apis*, *florea* and *dorsata*, the colony builds only a single comb, and "distance between combs" has no meaning.) (pp. 183-184).

Hives of all types can generally be classified into one of two categories--those which have moveable combs, and those which have fixed combs. The very earliest man-made hives were simply empty containers (such as a hollowed log), in which the bees attached their own combs in a non-moveable arrangement. Over time, beekeepers discovered new methods for manipulating their bees to a greater extent, still using this fixed-comb arrangement. Many of the world's so-called "traditional" beekeepers continue to use this type of hive today. The moveable comb type is said to have been widely used in Greece in the 1600's, and is described by Crane as follows: "(It) is like a round wastepaper basket, with a series of parallel bars covering the open top. The width of each bar is equal to the natural distance between combs, and the bees build a comb down from each bar. The hive walls slope inwards, as naturally-built combs do, and the bees do not attach their combs to the walls: each bar with its comb can be lifted out of the hive as a separate moveable unit." (Crane, 1977, p.184). The Greek basket-hive has persisted through time, and its basic design principle adapted to a rectangular type of hive body; known in this latter form as the Kenya top-bar hive, it was first tested by Mr. E.J. Treadwell and Mr. Peter Paterson in Kenya in 1967, and found to be quite suitable. Dr. Gordon Townsend and Dr. M.V. Smith of the University of Guelph, Canada, working on apicultural development projects in Kenya through the Canadian International Development Agency, suggested the use of the Kenya top-bar hive as a "transitional" hive which possessed many advantages over the traditional fixed-comb method of keeping bees in hollowed logs. The top-bar hive was found to be better-suited to the aggressive African bee, as there was less disturbance of the nest involved in working the bees; it allowed for greater wax production, taking optimal advantage of the A. mellifera adansonii tendency to forage and thus build combs at a faster rate; its simple construction and low cost made it attractive to many African beekeepers; its design permits horizontal comb-building, allowing for more effective temperature regulation of the brood nest in hot climates; and, it is capable of being suspended from the ground, to prevent many attacks by pests and predators. (Townsend, 1976c, pp.181-183). The most common type of hive in western Europe and North America is a moveable frame hive, developed in 1851 by L.L. Langstroth, and largely unchanged to the present day. Langstroth made practical his knowledge of the "bee space" (the distance required between adjacent combs, and between combs and the walls of a hive), and designed a system of precision-built hanging frames encased within a rectangular, wooden hive body.

This, then, was a moveable-frame arrangement which subsequently was utilized in stackable form, with the lower boxes constituting the brood nest area and additional honey storage boxes ("supers") placed on top, as needed. Langstroth's invention was hailed as a significant achievement which permitted more manipulations of the hive than were previously possible, and allowed beekeepers to learn a great deal more about the workings of their bees. Particularly in temperate climates possessing seasons in which heat conservation within the hive is a key factor in colony survival, the vertical format of the Langstroth hive is especially appropriate.

The preceding discussion may have suggested to the reader that there are many different pattern of reasoning which lie behind the choice of beehive, from one beekeeper to another. Crane states the following in this regard:

> Through the ages, beekeepers have had many ideas as to what bees require of a hive. Some of these ideas have been conservational: "I use such-and-such a hive because it is the hive my father and grandfather used." Some later ideas were anthropomorphic: "My door is downstairs, in the middle of the front of my house, and my bees would like the entrance in the same place." Fortunately, other ideas have been truly innovative, and these have a special interest for us today. (Crane, 1977, p.183).

Innovation in hive design is absolutely crucial to progress in this field because of the fact that each type of hive possesses its own productive opportunities as well as drawbacks; for example, some hives are more easily moved to pollination than are others; some facilitate honey production, while others may promote wax production; some may be readily hand-crafted with easily obtainable materials at low-cost, while others may be constructed of synthetic materials in a factory setting and be priced relatively higher; some hives may be better-suited to one species of bee than another, or to particular features of climate. Further experimentation on both a regional and individual basis will undoubtedly result in innovative honeybee technology, which will subsequently take optimum advantage of particular species of bees, their micro-climate, and the goals of the producer. In this manner, solutions to particular constraints imposed by each production situation may be devised, and potential economic benefits maximized.

Low-income nations should consider several important features of honeybee technology in the design of apicultural development programs: 1) The cost of hives and other beekeeping equipment should be minimized, to permit their adoption by beekeepers of even the lowest socio-economic levels. 2) Hive designs should strive to utilize readily-available materials (e.g. clay, wood, basketry stock) in a relatively simplistic construction. 3) Where a problem with unemployment exists, production of bee equipment should be planned as a labor-intensive process. 4) Technical designs should strive to allow for interchangeability of hive components to the extent that this is possible, and should consider international beekeeping organizations' recent interest in metrication of all designs and equipment.

Crane sums up world-wide activities in this important field of apiculture:

> ...We must come back to the question: where are we now going with hives? I think that advances in the immediate future will be on a very broad front. In the middle are the unexciting, but most necessary, movements towards standards, possibly world standards, for the hives in current commercial use. At one end of the advancing front are the low-cost hives--some traditional, some inspired by a renewed concept of self-sufficiency, and some devised specifically for their cheapness. At the other extreme are the high-rise and hyper-hives. It seems to me that useful developments may be achieved anywhere along the line: we must be ready to re-question the necessity for every hive fitting and part, and for every manipulation we make in dealing with bees and their honey. Above all, we must be continually open to new ideas, wherever they may come from, whether inside or outside the beekeeping fraternity. (Crane, 1977, p.189).

C. Management Practices

It may be said that there exist as many styles of apicultural management as there are beekeepers--due in part to the persistence of individual beekeepers to continue to do what seems to work well for them; but also to the fact that incredible variation in the micro-environment surrounding each apiary demands flexibility of technique, and a creative approach to problem-solving.

One should not ignore the fact, though, that some methods of management actually hinder opportunities for economic gain thru beekeeping, and need to be revised. This section will briefly point out a number of such examples, and suggest ways to eliminate or remedy these potential constraints.

First, one may recall from earlier sections in this work that each beehive is capable of producing a number of products: honey, beeswax, royal jelly, pollen, and propolis, and in certain circumstances, bee venom. Additionally, queens or worker bees in package form may be the target of productive efforts. In many cases, however, beekeepers are either unaware of markets for substances other than honey and/or beeswax, or choose to invest relatively too little time in these areas, purportedly believing that these "peripheral" products are not worth the effort required. Lack of information and proper training may be a limiting factor as well. Whatever the cause for disregard, it seems prudent to suggest that beekeepers in low-income circumstances should attempt to maximize their earnings from apiculture by considering the utilization or sale of every possible product from their hives. Included in this undertaking, then, is the minimization of wasteage in the process of regular colony maintenance, as well as during the extraction period. As beekeepers periodically inspect their hives, they often scrape excess amounts of both beeswax and propolis from their equipment and deposit these materials on the ground, to gradually decompose. Instead, a system should be devised to collect and later process these "scraps" for sale. Pollen traps can be adapted to many different kinds of hives, to similarly take advantage of excess pollen entering the colony and provide a high-value, nutritious substance for home use or subsequent sale. Apiculture programs of all kinds would do well to examine all such income-earning possibilities carefully, and seek to capitalize on those deemed most feasible.

Secondly, a system of record-keeping should be devised to chart colony progress in targeted areas, as well as to monitor such things as the floral calendar of the region, the weather, and so on. Information-gathering systems such as these suggested must take into account the range of skill levels of the individuals expected to use them, and should strive for both thoroughness and simplicity to the extent possible. Through such a system of management, the numerous variables operating within any beekeeping enterprise may be analyzed to yield information which can assist the beekeeper in future planning and decision-making.

Finally, management practices should make every effort to utilize information on traditional beekeeping methods, by adapting these concepts to more modern goals and procedures. In this way, development planners can expand their knowledge and appreciation of apicultural systems of many kinds; and, greater acceptance of new methods is more likely to result. This concept implies the active participation of local beekeepers in the development of strategies for technical improvement in their respective apiaries. Without such an approach, beekeepers may justifiably view suggested modifications with skepticism, severely limiting the opportunities for enrichment through apicultural development activities.

D. Product Quality

Although developmental efforts may be successful in increasing production levels of many honeybee products, one cannot expect to receive full recompense if the quality of the substance offered for sale is sub-standard. Therefore, great attention must be placed on production of the finest quality product possible. This section will discuss the role which this plays in determining the economic potential of apicultural development, and will cite the opinions of various authors on the subject.

Dr. Gordon Townsend comments on his experience in Africa, saying:

> The bee hives commonly used by central Africans consist of one chamber which makes it necessary for the bees to keep the brood, pollen and honey together. Whenever honey is taken out of this type of hive, the honey, wax, pollen, brood, and propolis are removed in one mass. The mixture of all these elements together makes it almost impossible to obtain a pure, marketable product. Often, in order to separate the honey from the wax, the whole mixture is heated over an open fire, with consequent burning and smoking. As a result, although East Africa produces thousands of tons of honey every year, the honey is usually badly prepared and unattractive in appearance. Because of this, its place in the

> local market is taken by imported honeys. If African honey could be properly prepared and distributed, there is no doubt that a ready, local market would be available.
>
> Africans are keen beekeepers, and there are many localities where beekeeping has been firmly established for a very long time. Although the East African honey is of good quality as long as it is in the hive, faulty handling from the time of its removal until it is put on the market is responsible for the inferior quality. The type of hive used, as well as the method of removing the honey, is responsible for this loss. From the information available, the same situation also occurs throughout most of central Africa and in many of the tropical areas of Asia. (Townsend, 1976b, p.85).

U. Meyer, speaking to an international conference held in 1977 on the subject of the development of world apicultural trade, discusses some of the problems faced by the so-called "developing countries" in exporting their honey. "The primary problems," he says, "have to do with quality." Meyer defines the basic criteria determining that quality as: 1) The expectations of the consumer in the market where the honey is to be sold, in regard to appearance, colour, consistency, and in particular, taste. 2) Legislative controls in the importing country, which regulate such matters as moisture content, tolerance levels for residues of pesticides and heavy metals, packaging and labelling regulations, and so forth. He then describes the common findings within the Federal Republic of Germany in regard to honeys from "developing" countries"

1. Problems with excessive moisture content, often due to the fact that the honey was extracted too early.

2. Honey which is unmarketable because its HMF (Hydroxymethylfurfural) content is too high, indicating the effect of excessive temperature or age on honey sugars; this is often due to improper handling during production and subsequent storage, or during transport.
3. Adulteration of honey, which is forbidden in the FRG, although it may not be illegal in the country of origin. This mainly involves the addition of glucose or unlawful additives.
4. Blending of honey from different sources or from several countries of origin in such a way that after pollen analysis it cannot be marketed.
5. Failure of the samples submitted to correspond in every respect to the actual quality of the consignment offered.
6. Failure to adhere completely to the specific details of the trade contract.
7. Honey packed in unclean containers, which then impart a disagreeable taste or contaminate the honey with foreign matter.
8. Improper or incorrect documents required for import formalities, which lead to delays and increased costs.
9. The figures indicating weight...often differ considerably in the country of origin and the country of destination. Since weight is the starting point for determining value for customs purposes in the country of destination, this again raises problems for the importer...

Meyer concludes his discussion with several suggestions on ways of reducing these problems in future trading. Included are the continued dissemination of technical assistance to honey-producing nations, concerning proper production, storage and transport procedures; a clear understanding and adherance to the laws of the consumer countries, and to the special requirements of the packers and distributors; and finally, increased information-gathering on the quality requirements of consumers in the importing countries, to assist the producer-countries in setting their goals and priorities. (Meyer, 1978).

These suggestions are particularly appropriate, due to the fact that the Federal Republic of Germany is one of the world's largest importers of honey and beeswax, as well as a leader in development assistance in the field of apiculture. Improvement in the quality of honey offered for sale would certainly enhance trading opportunities, and ensure higher prices in the marketplace.

Similarly, care must be taken to provide high-quality beeswax. Demand for this commodity exists on a steady basis, but only wax which meets importing countries' strict standards is acceptable. An address to the afore-mentioned conference on the development of world apicultural trade by R. Kortbech-Olesen and R. Dunning, both representing the International Trade Commission, focuses on this subject. They define beeswax as belonging to two distinct groups: wax produced by *Apis mellifera*; and wax produced in southern Asia, usually a mixture of *Apis cerana* and *Apis dorsata* comb, which is referred to as "Ghedda wax." Only the former is said to conform to the standards set in the industrialized nations, which are the greatest importers in this area. Crude beeswax may be procured in either bleachable or non-bleachable form, while refined wax may be yellow or white. Statistics at that time showed that the greatest preference exists for crude, bleachable wax from *Apis mellifera*. In this form there is a reduced possibility of purchasing an adulterated product; adulteration is most commonly accomplished through the addition of paraffin wax, which excludes it from use in both the pharmaceutical and cosmetics industries. In cases where supposed beeswax is found to be adulterated, it can then only be used by industries which can normally accept other types of wax, such as paraffin.

As is the case with honey, importing countries have regulations which specify minimum requirements for this substance. The authors mentioned specific problems in regard to both the high price of beeswax (as of 1977, tenfold the cost of paraffin) and great fluctuation in both price and availability, making it difficult for end-users to perform cost calculations with any degree of reliability. This, coupled with the problems of adulteration and sometimes sub-standard quality dramatizes the need for remedies in these areas. (Kortbech-Olesen and Dunning, 1978, pp.23-24).

Townsend has suggested that beekeepers may be encouraged to produce much better quality products through a system of grading, which incorporates a price differential. (Townsend, 1976b, p.85). In Kenya, such a setup offered a price comparable to the then-current world price for honey, if that honey offered for sale was of top-quality. Honey not meeting these standards was purchased, but only for about one-half that of the superior grade. (personal communication). Townsend emphasizes that a grading system of this type is a crucial element in improvement of hive products, and will not only encourage beekeepers to improve their methods of production, but may also stimulate more traditional apiculturists to switch to improved styles of beehives. (p.85).

Sufficient attention, then, to the quality of honeybee products promises considerable benefits for both domestic consumers and foreign importing concerns. Above all, it increases the likelihood that small-scale beekeepers in low-income nations will enjoy steady demand for their products, and that they will receive sufficient payment for their efforts, thereby contributing to opportunities for further economic progress.

SECTION III: FINANCIAL/ECONOMIC FACTORS

A. Product Prices/Competition

This section will focus on the two main products of the hive which are widely and actively traded throughout the world--honey and beeswax--and will summarize recent conditions of supply and demand which have affected the prices of these commodities. The effect of competition in these markets will also be examined, both inside and outside the beekeeping industry.

HONEY

The International Trade Center UNCTAD/GATT in 1977 estimated that world production of honey exceeded 800,000 tons per year, with less than 20% of this amount entering into world trade. Responsible for about 90% of these world honey exports were fifteen countries, half of which were "developing" nations. Mexico, China, and Argentina alone accounted for more than 50% of the export market in 1975. During the period 1971-1975, production fluctuated between 790,000 tons and 890,000 tons per year according to estimates gathered through the FAO Production Yearbook. (International Trade Center, 1977, p.iii, 11). Estimates on the 1980 world honey crop by the USDA stand at 732,000 metric tons, a value 1% below the revised 1979 harvest figure, and some 6000 tons below consumption requirements. Statistics show that there has been steady growth in world honey consumption, from 650,000 tons in 1976 to approximately 738,000 tons in 1980. Production on a world scale for export has not kept pace with this expansion, and this excess demand for honey has kept prices at a high, although fluctuating, level. (Crane, 1981, p.40).

The ITC, discussing factors which affect the world supply of honey, notes that a very small proportion of total production is sold for export. Their figures estimate that in 1975, Africa exported just 0.3% of their total, the USSR 3.6%, and in Asia 10.7%. Expansion of existing world supplies is constrained by the fact that many countries produce honey which does not meet the standards of the larger importers; by difficulties in honey collection, storage, and transport; by a shortage of trained personnel; and by limited marketing experience. Apicultural development within these countries of high production potential is expected to increase the supply of honey on the world export market, but only slowly. The next five to ten years are expected to reflect progress in this vein.

The increase in world demand for honey is attributed to such things as the improvement in standards of living within the industrialized nations; the growth of consumer interest in natural and healthy types of food; the successfulness of some "aggressive" marketing policies by packers and retailers in certain markets; and, the emergence of new importing countries such as Japan, which was at one time a net exporter of honey, attributed to some degree of Westernization of the Japanese diet.

The interaction of such supply and demand factors has resulted in a shortage of honey since 1970, and a considerable increase in prices over this period. Demand, however, has not slackened, making this largely a seller's market. (International Trade Center, 1977, p.15). Import prices are determined by such factors as the honey's quality, botanical source, color, composition, flavor, suitability for blending, and form (e.g. comb honey, chunk honey, extracted honey). Additional price factors relate to the country to which the honey is sent; for example, certain European nations are willing to pay high prices for quite dark honeys, while the United States prefers lighter varieties and offers a lower price for the darker types, reserving them primarily for industrial uses. Prices are also influenced by the availability and current market prices of acceptable substitutes. Such competition is largely from jellies and jams, syrups, and artificial honeys, especially among consumers who are very price-conscious and who think of honey as simply one more type of spread, rather than a natural and healthful product. A smaller number of persons are prepared to buy honey despite its sometimes higher price, and there is evidence that the health food movement is causing this number to increase steadily. Imported honey also competes with domestically produced varieties; in most countries which produce some honey, domestic supplies are rated as top-quality and are sold at premium prices. But in many cases, the competition between foreign and domestic honeys is reduced by their difference in price and concurrent demand for these two categories by different groups of consumers. (pp.18-19).

There are basically, then, two market segments for honey. The first is that of table and household consumption, which forms the bulk of the market and is enjoying rising demand. The second is honey used for industrial purposes, which has seen some decline in demand since the mid 1970's due to high honey prices and the current availability of lower-priced substitutes such as isomerized corn syrup. Industrial honey is used primarily in the cereal, bakery and confectionary industries, with other limited quantities purchased for use in baby food, tobacco products, pharmaceuticals, and cosmetics. (International Trade Center, 1977, p.3).

BEESWAX

Estimates from a 1978 report by the International Trade Center UNCTAD/GATT place total annual beeswax production at approximately 11,500 to 19,000 metric tons, while the amount entering the world marketplace was just 5,000 to 5,500 tons. (International Trade Center, 1978, p.iii). This limited amount constitues a severe shortage, especially for industries which cannot substitue other types of waxes for beeswax. Conditions during 1977 believed to contribute to the shortage of supply included Angola's failure to provide their usual amount of exports, due to political difficulties; reduced supplies from Ethiopia, and for the same reason; and supposedly reduced crops in other parts of the world. (p.7). Additionally, the report notes that a great portion of potential supply is neglected, either due to lack of appreciation for its value in foreign exchange, or because the beekeeping industry reuses the wax in the making of comb foundation for modern-style hives. (p.9). One must also consider the fact that a significant portion of the wax produced in Asia, so-called Ghedda wax, is unacceptable to most importing countries and does not, therefore, contribute to total supply for export. Further contributing factors include a lack of trained personnel in this field, and a corresponding shortage of proper information on marketing opportunities and procedures. (pp.11,13).

Statistics collected over the period 1972-76 illustrate the role which low-income nations have played in supplying the world's seven largest importers with beeswax. The top fifteen countries in this category include Ethiopia, Chile, Tanzania, Brazil, Morocco, Mexico, China, Kenya, the Dominican Republic, and Madagascar. Apicultural development activities within these and other countries increase the likelihood that beeswax of export quality will be produced in ever-increasing amounts, provided that political and meteorological conditions do not hamper production efforts to too great an extent. (International Trade Center, 1978, pp.12-13).

Demand for beeswax is concentrated among the higher-income, industrialized nations of the world; during the years of the 1972-76 survey, the top seven nations in this category were the United States, the Federal Republic of Germany, the United Kingdom, Japan, France, the Netherlands, and Switzerland. Total imports by these nations accounted for approximately 80-90% of the total international trade in this commodity. In this same period, the United States and the Federal Republic of Germany accounted for over half of this world total. Although fluctuations in the quantity purchased by each country annually did occur, trade sources available to the ITC indicate that world consumption did not vary in such proportions, indicating that changes in stockholdings, rather than useage levels, were responsible. (International Trade Center, 1978, pp.9-10).

As mentioned in the previous section on product quality, beeswax is sold on the world market as either "crude" or "refined," and may be described as of "bleach-able" or "unbleachable" form. Statistics indicate that prices for bleachable wax are higher than non-bleachable types, with lighter colored wax bringing a higher price than darker stock. Ghedda wax is traded in limited quantities, but costs far less than beeswax from Apis mellifera. An ITC study cited prices from 1976 as listing the price of crude African beeswax imported by Japan at $3,300 per metric ton; 1977 rates show crude beeswax imported by Europe as costing $3,850 to $4,200 per metric ton, while refined wax sold to Europe would cost $4,300 to $5,300 per metric ton. Both of these 1977 prices were quoted during the months of February through March; but by October of that same year, import prices for crude wax sold to Europe were quoted at $5,000 per metric ton, illustrating the rapidity of price escalation in this market in times of short supply. (International Trade Center, 1978, pp.18-19).

Studies indicate that the cosmetics industry is the largest consumer of beeswax (35%-40% of total imports), followed by the pharmaceutical industry (with 25%-30% of total imports). Candle manufacturers make up the third basic market segment, using about 20% of all imported wax. The remainder is used for polishes, dental equipment, armaments, confectionery goods, castings, and lithographic and engraving materials. The constantly-fluctuating and often-increasing price of beeswax is a matter of great concern to all these industries, and in many cases substitutes are being sought. (International Trade Center, 1978, pp.13-14).

Strong competition in today's markets comes from paraffin wax, microcrystalline waxes, and synthetic waxes (including synthetic beeswax). These may cost one-tenth the price of beeswax, are generally plentiful in supply, offer attributes such as uniform color and quality, and are subject to less price fluctuation than is beeswax. This competition has its limits, however, since the unique properties of beeswax make substitution in many cases impossible. (International Trade Center, 1978, pp.17-18).

SYNTHESIS

The preceding discussion has endeavored to document the fact the both honey and beeswax are high-value commodities in great demand within world markets, constituting a considerable opportunity for currently-producing areas, or others now planning the expansion of their apicultural development activities. An important point must be made however, in regard to incentives for producers: Unless subsistence-level beekeepers in low-income nations receive sufficiently-high prices for quality honey and beeswax, production levels are not likely to rise to the extent desired. But a combination of price incentives, coupled with technical assistance in product improvement, has been shown effective in producing the desired result. Increased supplies of honey and beeswax, improved incomes for beekeepers, better product quality, and heightened opportunities for foreign trade in these commodities--the probability of these and other benefits has its roots in attractive and equitable prices for beekeepers' products.

B. Availability of Credit

Previous sections of this work have discussed the benefits of minimal investment requirements for a start in beekeeping--and this is, indeed, a point worth emphasizing. But further impetus to growth and development of the apiculture industry may be given through the increased availability of credit to small-scale beekeepers, including those lacking substantial collateral, in many cases; and this section urges the consideration of this fact in the development of all beekeeping programs.

Only scanty literature is available on apicultural credit in low-income nations; therefore, presentation of the details of such programs, and contrasts of relative effectiveness are not presently possible. But one may theoretically pursue the concept of credit extension to subsistence-level beekeepers, and consider the merits of such action.

One valuable source on this topic confidently asserts, "Among the agricultural credits, the surest one is that which is advanced to apiculture..." (Ordetx and Perez, 1966, pp.632-633). Extensive evidence to back up this claim is lacking in their presentation, but the authors do state, "When it is a question of small loans, the development institutions consider the (beekeeper) as an indirect principal guarantee. Then they investigate the profitability, and finally the physical guarantee.

Among apiculturists there cannot be a better procedure than this; and after several years of our experience, we can say that the losses--occasional--are of very small importance. The apicultural credit in materials and utensils is one of the surest agricultural credits, provided the pay-back is also in kind." (p.634).

Ordetx and Perez explain that apicultural credit was not a part of the general program of agricultural credits to small farmers in Central America until the mid 1950's and '60's. When it became apparent that such a need existed, credit programs were devised in Cuba, Honduras, the Dominican Republic, Mexico, El Salvador, Nicaragua, Costa Rica, Guatemala, and Panama. In many cases, large-scale development banks funded these programs, and assisted would-be producers and practicing beekeepers in building honey and wax processing plants, honey packing plants, and modern apiaries of varied scale. In mose cases, lending institutions felt that the lender's bees, honey and wax crop, and beekeeping equipment constituted sufficient guarantee for the loan, especially when the amount of credit extended was small. For operations exceeding 500 hives or so, additional guarantees were sought, but the nature of these is not specified. The authors express the opinion that the benefits of such credit were substantial, indeed; and the concept of credit for small beekeepers spread to the above-mentioned countries on a gradual basis, once a successful reputation in this area was established. (pp.619-634).

One may also wish to consider ways in which persons with limited financial resources who wish a start in beekeeping with one of the "improved" types of hives (i.e., requiring purchase, rather than one self-made of freely available materials), can be assisted through a program of credit. Dr. Gordon Townsend has suggested a system whereby the interested party may approach training personnel at an apiculture project's demonstration apiary, and begin a system of internship to learn the basics of hive management. This may be accomplished through periodic visits, at the individual's own pace, until training personnel feel that the beginning beekeeper has sufficient knowledge with which to proceed on his/her own. The individual can then be given the right to manage the colony, which will still remain at the training facility's headquarters, until s/he produces a sufficient crop to equal the established value of the hive. At that point, the hive will be turned over to its new owner, and re-established at its new location. Such a program has been tried repeatedly in Africa, with good results. (Townsend, 1981b).

These and other types of programs require one important feature--that is, they must make available a start in beekeeping to all interested parties, regardless of economic status, on at least a small-scale level, and seek to combine this financial opportunity with sufficient training and experience requirements, to reduce the risk of failure.

Larger loans are generally the prerogative of commercial beekeeping operations or cooperatives, and would generally have different needs than would subsistence-level individuals. In any case, persons planning apicultural programs must endeavor to secure some kind of credit opportunities for small-scale beekeepers if, as is hoped, widespread involvement is a program objective.

SECTION IV: ORGANIZATIONAL FACTORS

A. Collection Centers/Central Processing Plants/Co-operatives

Sections which have discussed the actual processes involved in apicultural production, the quality of hive products, and supply and demand issues have alluded to the fact that a key to successful organization of an area's beekeeping potential is the establishment of centers which can function as collection points for small-scale beekeepers who need technical assistance in the processing and marketing of their products. Experience has shown the regional collection center concept to be one of the most practical ways of meeting numerous program objectives, which include the increasing of local production (and therefore supply), the improvement of product quality, the organization of groups of beekeepers, and the facilitation of marketing. This section will explain the concept behind the establishment of such collection centers, and detail some of the important organizational concepts found useful in previous apiculture programs.

Dr. Gordon Townsend, a strong advocator of this approach, describes the background of these centers, and their common requirements:

> The history of honey collection centres established in East Africa has not been a successful one, except for a few instances. They seem to thrive for a few years and then disappear. The main requisite for success seems to be a strong central marketing organization, or a government section responsible for the overseeing of apiculture developments within the

country. In this way, the organization can be assisted over its rough spots, and necessary supervision of the technical operations provided. The ideal organization would appear to be a central processing and packing plant supported by satellite collection centres in the main areas of production, backed up by a government extension service of well-trained personnel.

There are several main requisites for the success of a collection centre. The overall scheme must be in a position to purchase honey over the short period of the season, and sell it over a longer period. It is important that the beekeeper be paid in cash for his product when he brings it to the center. In order to encourage production of a better quality honey, there should be a price differential according to the grade of honey. This will encourage the beekeeper to improve his production methods, and possibly to change to a different type of hive which is more adaptable to producing quality honey...The collection centre itself is best organized as a co-operative, made up of representatives from the collection centres involved. Organizations of this nature would, in many cases, be in a position to borrow money so that they can carry on cash transactions for the honey and wax supplied. In all collection centres, provision should also be made for handling beeswax, and this should be encouraged as a major beekeeping commodity, particularly in Africa. (Townsend, 1976b, pp.85-86).

Townsend emphasizes that the capability of paying the beekeeper <u>in cash</u> when the products are brought to the center is very important. This, he feels,will impress upon the beekeeper the fact that apiculture can provide a ready source of cash--and will thus provide a further incentive to produce additional honey and beeswax. He advises the establishment of a revolving fund of some sort, which will possess sufficient funds to make these cash payments for the anticipated volume of business, and will be suitably replenished as honey-bee products are sold.

The details of the physical plant requirements are then given:

> A honey collection centre could vary... from a simple bee-tight buidling where honey is purchased on a graded basis and taken to the central refinery, to a small building equipped with minor straining facilities and provision for the first refining of the beeswax. No matter for what purpose, the site is important. It should be convenient to the area of production, adjacent to or on an all-weather road; it should have an abundant supply of water, and it should be placed on well-drained gound. The plant should be built of brick or stone, and roofed with galvanized iron or similar material. It should be ant-, bee-, and vermin-proof. It should be well-ventilated, and it should be provided with rain water tanks, because rain water is the best for refining beeswax.
>
> Since honey is not as perishable as milk, supplies brought to the centre can wait several days before being refined or shipped to the central packing plant. In most cases, the honey collection centre will require a means of separating honey from wax or pressing honey from comb, as well as equipment to refine to beeswax partially, into moulds. If the moisture content of the honey is high, heating equipment will be required, both to strain the honey and to raise its temperature sufficiently to destroy yeasts which may cause fermentation...If the collection centre is to provide a local market with honey, then some provision should be made for the filling of bottles. A bee-proof, ant-proof locked storage for both wax and honey, prior to shipping or collection, should also be provided. (Townsend, 1976b, p.86).

Collection centers of this type should be located in such a way within the larger-production areas that beekeepers need not incur substantial transportation costs to sell their products. The establishment of sites for both the collection centers and the central packing plant should be considered during the feasibility study, preceding the actual initiation of an apicultural development program. In regard to the somewhat different requirements of the central packing plant, Townsend advises:

> (It) should be located somewhere near the major market for honey; it would be much larger, and with more equipment for the handling of honey. It would have more-elaborate heating and cooling facilities, as well as settling and straining equipment...This phase of the programme could be operated in many ways: it could be operated as a co-operative associated with the honey collection centres; it could be operated by the government; or it could be operated privately or through one of the mission-oriented organizations. For financing, possibly the best approach is through the central co-operative, which would make available certain amounts of money for each collection centre to make their purchases. The central organization could also have associated with it the manufacturing of beekeepers' supplies, so that these could be taken out to the collection centres for sale when the trucks are going out to fetch honey. (Townsend, 1976b, p.86).

Because the satellite collection centers and central processing plants provide solutions to many of the problems likely to be encountered in an apicultural development program, the extent to which these or something comparable are implemented will likely determine overall program success, from at least an organizational point of view. Moreover, the tendency toward co-operative development has proved an additional asset, as producers share the benefits of their progress and receive a good price for their efforts. As word of the success of this approach spreads, there is every likelihood that the concept described will be a model for many future projects in apiculture.

B. Marketing Development

The high level of demand for honey and beeswax assures producers of ready markets for their products; but improvement in marketing techniques, and especially product promotion are required, to assure that the high cost of these commodities does not result in extensive substitution of other products in place of honey and beeswax. Correspondingly, if bee pollen, propolis, and royal jelly are to become more important economically, present markets for these substances need to be expanded and additional market opportunities sought.

The International Trade Center UNCTAD/GATT emphasizes that once a bad reputation is developed with importing countries or other trading partners, it is difficult to repair. They therefore advise that great care be taken to assure the integrity of the products intended for sale (mainly by avoiding adulteration problems), and that contracts made be adhered to in all respects. They urge exporting countries to establish regular trade channels through reliable agents and importers in appropriate markets, since such persons generally prefer to make long-term arrangements and receive shipments on a regular basis. In deciding what types of distribution channels might be used, the ITC suggests that exporting countries consider things such as the stage of development of the beekeeping industry; the quantity and quality of the supply; the nature of the target markets, and their respective regulations; and, the level of marketing experience in the exporting country. Distribution channels may range from agents and importers, to direct sales to packers and industrial users, or even to the exporting nation's own sales organization. The latter option faces stiff competition from established businesses in this area, and the ITC suggests that a great deal of experience should precede the setting up of an exporter's own sales group. (International Trade Center, 1977, pp.4-7)(International Trade Center, 1978, pp.19-23).

Crude beeswax is usually imported in jute bags containing quantities of 50 to 100 kb. Large-scale importers do not often purchase less than five tons at one time, and prefer 20 ton lots. Smaller importers usually buy 2 to 5 tons at a time. The ITC survey revealed that no quantitative restrictions were placed on beeswax imports into the major markets, although some customs duties were occasionally levied, but these were generally quite low. In many major markets, beeswax may enter either duty-free, or at reduced tariff rates. (International Trade Center, 1978, pp.14-15).

Honey is commonly imported in 300 kg. drums, in smaller-size lots of 25 to 30 kg., and when bought by large importers, in tanks which will hold several tons. If the honey is already packed for sale, small jars of 450 to 500 g. may be used. With few exceptions, there are no quantitative restrictions on honey imports into the major markets; however, customs duties are commonly added to imported honey in order to encourage domestic production. Honey may be marketed as either monoflora (predominantly from one floral source), or as polyflora (from more than one floral source). The price of monoflora honeys is usually the higher of the two; but the production of monoflora honey requires special field conditions which may be difficult to manage; and, the flavor must be one which appeals to a wide number of consumers, or it will not sell well. Therefore, most countries just entering the export market will wish to concern themselves with up-grading the quality of their polyflora honey initially, and establishing a good reputation for their product, before moving on to monoflora types. (International Trade Center, 1977, pp.4-6).

Discussion of the export market is not intended to suggest that domestic marketing of bee products be over-looked; quite the contrary, promotion of beekeeping and the consumption of domestic honey go hand-in-hand, and substantial effort should be extended in this direction.

Just the same, local industries should be encouraged to purchase domestically-produced beeswax, if the need exists. In some cases, products which meet strict export standards may be exchanged on the world market, while those which do not may be sold locally at a domestically-affordable price. The system of honey grading which has previously been suggested could conceivably determine which stocks are candidates for export, and which others should be sold locally. Honey marketing organizations should be extremely active in promoting their products, and in distinguishing the value of honey as opposed to possible substitutes.

The possibilities within this particular area of apicultural development are very broad, indeed; and strategies for effective marketing of honeybee products must be tailored to the particular set of conditions at hand. In many cases, persons with special training in marketing would be a very wide investment; but where this is not possible, a carefully-planned trial-and-error procedure may find good success in domestic markets. In any case, marketing should be viewed as one of the most important stages in program development, and a great deal of effort directed toward the solution of recognized constraints in this area.

C. Extension and Training Services

Although many of the objectives of apicultural development are basic ones shared by nearly all projects, such as increased production of hive products, improvement of product quality, and enhanced economic well-being through apiculture, the important features of organization of extension and training services in this field center on the careful tailoring of extension strategies to the conditions and goals of the area under consideration. Priorities may range from concentration on pollination of agricultural crops, to emphasis on wax rather than honey production, or again to the stimulation of rural employment through beekeeping development. In any case, apicultural extension services should strive for flexibility in approach, and should be designed and function in such a manner as to adapt to the range of needs of beekeepers in the area.

This is not to suggest that regional or national goals in apiculture can be arbitrarily arrived at; for in most cases, conditions prevailing in the area will shape the types of options available to development planners. These conditions may include such things as: 1) the quality of local bee stock; 2) interest shown by the government; 3) interest shown by beekeepers and honey hunters in modification of techniques; 4) transportation and communication services in the area under consideration; 5) natural language barriers; 6) the availability of suitable training locations for skills improvement; 7) funding accessibility.

Many countries have found the establishment of beekeeping demonstration centers to be extremely useful, as they provide locations at which appropriate methods of colony management can be effectively taught. In Tanzania, for example, beekeepers may stay at these centers for two-month periods of practical training, after which time they return to their village apiaries to disseminate their knowledge to others, and practice newly-developed skills. (Ntenga, 1976). Similarly, Tunisia has established regional demonstration apiaries in areas of that country most favorable for honey production, and has gone one step farther in making training in apiculture available to students at elementary, secondary, and post-secondary schools. (Popa, 1979). The concept of introducing students to the practice of beekeeping at a young age is fast spreading; Mr. David Gooday, working on behalf of the World Bank in West Africa's agricultural education programs, recently stated his resolve to propose the introduction of apicultural training to the present curriculum format for the whole of that region. (personal communication). Schools provide a somewhat more convenient system, in that students are already committed to a certain period of time away from the home and can combine beekeeping training with other learning activities; while persons not already enrolled in a school program may find it much more difficult to commit a portion of their time to attend training sessions. It is important, therefore, to consider the ability of the target group to attend either formal or non-formal training sessions, as well as the advisability of an extension service which visits potential or practicing apiculturalists at their apiary sites, thus eliminating the need for the beekeeper to spend time away from his regular pursuits.

Many different methods may be employed in the disseminating of helpful information. Radio and/or television programs could carry talks on beekeeping topics, and advertise hive products to potential consumers--this of course would depend upon the extent to which this technology is accessible to beekeepers and consumers. In Tanzania, special cinema vans have been outfitted to show films on beekeeping in rural areas throughout that country. (Ntenga, 1976). From several Indian authors comes this advice:

> The media commonly used for the spread of apicultural know-how are books, journals, leaflets, films, radio, exhibitions, demonstrations, and so on. In tropical countries all these media have their own limitations. The percentage of literacy in the tropical region is very low. Even presuming that the population is able to read and understand literature, it will be a herculian task to produce technical literature in umpteen number of languages. Exhibitions, film shows, radio talks, and demonstrations are indeed very useful and effective methods of dissemination of knowledge. But, they are very expensive and usually it is found that these measures are more frequently advocated than practised in developing countries. The most effective means of transfer of know-how in beekeeping, as found

> to have succeeded in India, is demonstration by the neighbor beekeeper. A successful beekeeper is the most effective training unit for all practical purposes. All the departmental and institutional training programmes, therefore, should be to generate and encourage such successful beekeepers to function as extension units. (Yesuvadian, Aruldhas, and Christopher, 1978, p.28).

Whatever the approach (or combination of approaches) used, extension and training services should be based on careful evaluation of regional beekeepers' many developmental constraints, such as those which have been discussed in this paper. A keen understanding of these constraints, in addition to the expressed needs of the beekeepers themselves, should guide the development of programs which will hopefull remedy many of apiculture's regional limitations.

D. Regional Research Capabilities

As in any area of science, there are many more unanswered questions than there are resources to answer them suitably--and the field of apiculture shares this dilemma with numerous other disciplines. Although a great deal has been learned about the honeybee, especially in the last one-hundred years, a great deal more is yet unknown; and this is particularly true in regard to the lack of information on Apis cerana, Apis dorsata, and Apis florea, as much of the present data base rests on studies of European and North American Apis mellifera. Likewise, the botany of the tropical regions is less understood and there is much study needed in this area, so as to improve the forage crops for species in these locations.

Apiculture as a development activity is yet in its infancy; and discussion of factors which limit progress in beekeeping has often touched on topics requiring further work and study. This section does not seek to recount the many needs which exist--but rather, chooses to emphasize the need for regional development of research capabilities; for it is only in this way that the diversity in the honeybee and its environment may be suitably investigated, and made applicable to the problems of local beekeepers. Researchers should endeavor, to this end, to conduct their research activities amongst practising apiculturalists--not apart from them. Much of the information desirable from a research standpoint may be the ready knowledge of local beekeepers, if only it is sought. Or where facts appear unknown, research efforts may be shared by enlisting the help of these local persons in activities which stand to benefit them, either directly or indirectly. In this way, results obtained through research should be exchanged with the extension and training services, in order to disseminate new findings; just as the extension and training components must constantly communicate the information/research needs of their beekeeping clients to persons who direct such research. Likewise, there is a pressing need for economic studies in many areas of apicultural research, to assist in the translation of research findings into economically-sound development activities. Through the development of these capacities at the regional level, research can be pertinent to the area in which it is conducted, and can enrich our understanding of the great variety inherent in the field of apiculture.

E. Institutional Linkages

In any area where beekeeping develops in an organized manner, it will be necessary for the leaders of apiculture projects, beekeeping co-operatives, and the like to develop relationships with other organizations. These relationships are what may be termed "institutional linkages." Axinn has described four types of institutional linkages:

1) enabling linkages, to organizations which "provide authority to operate, and access to essential resources."

2) functional linkages, which "provide the needed input into the organization, and take away its output."

3) normative linkages, which are "relationships with other organizations which share overlapping interests in the objectives or the methods of the institution."

4) diffuse linkages, or "relationships with individuals or groups who are not organized in a formal organization, but they do influence the standing of the institution itself." (Axinn, 1978, pp.160-161).

Beekeeping organizations might be expected to establish institutional linkages with such external groups as universities; Ministries of Agriculture, Education, Animal Resources, and Forestry; international apicultural organizations; and so forth. Relationships with these outside groups may range from being supportive or reinforcing, to being quite competitive or even hostile. In any case, substantial effort should be expended to developing useful ties to institutions which may fall into either of the four categories previously detailed. To some extent, the successfulness of this process will be reflected in the ability of the apicultural organization to become sufficiently institutionalized to withstand the development cycle. On the other hand, failure to consider and develop these external relationships tends to result in structural weaknesses which may eventually destroy the infant institution. Planners should carefully consider these organizational relationships with outside groups, and foster those which are critical to apiculture's growth and development.

Currently one of the most important and helpful institutions in the field of apiculture is the International Bee Research Association (IBRA), located in Gerrards Cross, just outside of London, England. It functions as the central clearing-house for all types of information on bees and beekeeping, as well as related topics. In addition, it publishes three journals, and operates a lending library for all Association members. Co-ordination of international conferences on tropical apiculture is now a regular function of this group. Its director is Dr. Eva Crane.

Another valuable international federation of beekeepers is that of Apimondia, consisting of at least 63 member nations, which meet regularly as the International Congress of Apiculture to discuss issues of beekeeping technology and equipment, bee pathology, melliferous flora and pollination concerns, bee biology, and beekeeping economy. Apimondia publishes the reports of these meetings, as well as other useful information to apicultural organizations. Their headquarters is located in Bucharest, Romania.

There are also international development organizations which have begun to recognize the merits of apiculture in low and middle-income nations, and have assisted in important ways. UNESCO has, among other things, granted funds to IBRA to conduct a survey of world honey sources; FAO is presently funding a comprehensive book on international apiculture for rural development, entitled Apiculture and Honey Production in the Developing Countries of the Tropics and Subtropics. Specialists from around the world are collaborating on this effort, which is soon to be published. Also, in 1977 and 1978 the International Trade Center UNCTAD/GATT conducted market studies on beeswax and honey, in hopes that so-called developing nations could benefit from the information; and also in 1977 jointly sponsored, along with Apimondia, an international conference on the "Development of World Apicultural Trade."

Various development groups within some of the higher-income nations deserve recognition in this context as well. The Commonwealth Secretariat of Britain has published a book entitled, Beekeeping in Rural Development--Unexploited Beekeeping Potential in the Tropics: with particular reference to the Commonwealth. The Overseas Development Administration, also from the United Kingdom, has generously assisted IBRA with its efforts, as has the Commonwealth Foundation. The Canadian International Development Agency (CIDA) has been a keen supporter of apicultural development, and has channeled much of its technical assistance through the University of Guelph, Ontario; particular success on their part must be noted in the case of Kenya, which stands to be a leader in this field in tropical Africa. The German Federal Republic's Agency for Technical Co-operation (GTZ) has also provided a great deal of technical assistance to develop national programs in apiculture; New Zealand has played a similar role in initiating honeybee projects in the tropical and sub-tropical areas of the Pacific. This list is by no means all-inclusive--there are many smaller organizations which have also supported apiculture's development as well. Through years of experience, many of these organizations are continuing to enhance their abilities to assist interested nations in the best possible way. Such institutional linkages are providing an important ingredient to the apicultural development process, and are to be congratulated for their continuing efforts in this field.

SECTION V: ADDITUDINAL FACTORS

Earlier in this paper, discussion of some possible reasons for lack of attention to the vast potential of apicultural development was presented. (see pages 50-51.). These attitudes must be viewed as serious constraints which can hamper further development, and which must therefore be remedied. A key factor in improving public understanding of the important role honeybees play in agricultural production is the need for broad-spectrum education on this topic. Schools, mass-media resources, political lobbying--and and all possibilities should be investigated and implemented. General phobias about insects need to be dispelled, in favor of real knowledge of the role beneficial insects play in our ecology. Research results showing the productive advantage of using honeybees for pollination and/or honey and wax production in both rich and poor countries need to be published with greater frequency. The success of many apicultural development projects in increasing economic well-being and rural progress must be made known to donor organizations throughout the world, to increase the chance that they will become active in this field. Through such educational efforts, apiculture can hope to enlist the enthusiasm and support it deserves.

SECTION VI: ECONOMIC FORECAST FOR APICULTURAL DEVELOPMENT

Forecasting, by its very nature, tends to be somewhat imprecise and even tainted by the inclination towards either optimism or pessimism on the part of the speculator. But in conclusion to this paper, it seems useful to look perhaps ten to fifteen years ahead and to ask ourselves what the future appears to be for apiculture, as an economic activity in low and middle-income nations. Although one might cite any number of opinions on this subject, this author has chosen to utilize the remarks of Dr. Gordon Townsend, whose involvement in this field over many years makes him a valuable source of ideas about the future. He says in this regard:

> We are just seeing the beginning of vast changes in the beekeeping industry...Man, not the bee, has brought about these changes and we will continue to see the effect of his activities..
>
> The great potential for increased production of honey lies mainly in Africa where, up until recent years, most of the beekeeping has been of a primitive nature, yet is very extensive... Many of the countries of Africa are now becoming aware of their potential and are making efforts to expand...The African bee, with its ready source of supply of bees, its migratory habits, and adaptability to a cheaper hive, creates an ideal situation for beekeeping among rural people, where they can operate 4 to 10 colonies of bees and thus materially supplement their income. This is going to be the trend throughout many parts of Africa, and I believe that the same thing might happen in South and Central America, at least in the tropical areas. It will be many years before most of the African countries meet their own demands for honey, but eventually they will be reaching the export market; this, at least on a large scale, is ten to fifteen years down the road, and will likely find Europe as its major market...

...I look upon America...as being eventually a large importing area as far as honey is concerned, so we will be dependent upon other areas for much of our supply. No doubt, most of this will come from South America. The picture in South America, however, is not clear as yet... The movement of the African bees through South America and into the Central American area will pose real problems as far as production is concerned from a commercial point of view...It is my prediction that the type of beekeeping that will be carried on in the tropical areas of South America and Central America, including Mexico, will be very similar to that which is carried on in Africa...Honey will be produced by large numbers of beekeepers operating on a small scale, handled through collection centers.. There will likely be, on the short term at least, an increased supply of beeswax, accompanied by a shortage of honey on the world market as the African bees move north through Mexico.

The present and future energy problem will not be without its effect on beekeeping. Migratory beekeeping will likely be reduced as the cost of moving and changes in farm practice take place. More use of legumes in rotation will be necessary to reduce the costs of nitrogen fertilizer...This change could materially improve honey crops in the eastern U.S. and Canada, where corn on corn has been the general practice.

The same pattern is already developing in the tropics where the term "Agroforestry" has become quite common. Here legume-type trees, some of which are good nectar producers, are being used. The trees are producing both fodder and fuel, as well as fixing nitrogen in the soil. Some of these trees will grow as much as 20-30 feet in three to four years, and come into bloom with very little moisture requirement. They will open up vast areas not being used at the present time to both beekeeping and livestock production. Of particular interest for such development is the Sahel region of Africa and some of the coastal areas of Chile and Peru...

In summarizing, it is my opinion that most of the northern hemisphere is going to find it difficult to produce even their own needs of honey in the future, and many of these countries will continue, or increase, their imports of honey. We will become more and more dependent upon our imports from the tropical and semi-tropical

> areas of the world...it will be recognized that beekeeping can be one of the major sources of rural income. (Townsend, 1981a).

Townsend's opinion that the greatest opportunities in apicultural development lie in the tropical and semi-tropical regions of the world is shared by many specialists in this field. If they are correct, the economic potential inherent in such advances is staggering--to say nothing of the possibilities for better yields of many entomophilous crops through bees' presence in agricultural areas. Hopefully, this work has suggested the need for rural development planners and others to take a hard look at this freshly-emerging field of work, and to contribute toward making these exciting possibilities real.

CONCLUSION: CURRENT NEEDS IN DEVELOPMENTAL APICULTURE

Almost every aspect of apiculture is now growing and expanding--to the extent that "current needs" are really infinite in scope--and, rather than attempting to present an exhausting list of deficiencies, this author deems it more pertinent to address a single gap which demands attention from apiculturalists around the world.

Most of the literature available on apiculture as a development activity comes to the reader as either a single article, usually of one to ten pages or so, or as a collection of these short articles in book form. Other books have addressed the topic of "honey" or "honeybees" in more comprehensive fashion, and have included a smattering of information on beekeeping development projects--but usually no more than this.

The projects and programs discussed in the course of this paper may accurately be viewed as only a portion of all those which exist; and this represents a vast source of information which could be helpful to other projects already underway, as well as to future efforts. Yet, what one is likely to read about any single project is merely a brief summary of a given period's activities. This author sees the need for more detailed case studies of these projects--studies which would explain the background efforts undergone in establishing the project, in staffing it, in funding it, in deciding on the scope of activities, in implementing those decisions--and so forth. For it is the accumulation of these everyday events which may make or break a project, at any stage; and case studies which can discuss the results of actions taken in the course of the project, both successful and unsuccessful ones, have much to offer the world of apicultural development which is not now available. The exchange of this kind of information could not only demonstrate particular types of approaches which tend to work well, but could also illustrate the variety of successful methods. Common flaws might also emerge, alerting others to the possibility of comparable hazards within their own programs. Whatever the results might be, the need for critical appraisal in detailed fashion of apicultural development programs is an acute one--and at the same time, is a tough gap to fill. For scrutiny of this kind requires that detailed records and personal observations from both managers and staff be maintained; and again, it takes time to see the effects of decisions made at an earlier stage, and to evaluate them with sufficient perspective. All the same, efforts in this direction are to be applauded, as they will contribute invaluable information which can serve to improve the quality of apicultural development programs--and thereby heighten the interest of organizations throughout the world in undertaking similar projects in beekeeping.

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