A Manual
of
Tropical Butterfly Farming

By

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Contents:

1. Butterflies – An Introduction:

1.1 General:

Butterflies are classified among a large group of insects known as the Lepidoptera meaning “scaly winged” from the fact that all members in this group have their wings coated with tiny feather like scales that are attached to the wings in rows like tiles on a roof. These scales are coloured often brightly and give the butterfly its beautiful patterns. Sometimes I am asked about the ‘powder’ on butterfly wings, because that is what it appears to be, but in fact under a high power magnifying lens or a microscope the scales are seen to be very detailed in design. Scales vary in size but a normal size will be about a fifth of a millimetre long, and it takes about a quarter of a million to cover the wings of a butterfly. The value of the scales to a butterfly are not entirely clear, but of course they allow the butterfly to maintain its colouration which is essential for recognition by other butterflies, and in the case of the males some of the scales carry chemical scents which are essential to the butterfly in mating. The beautiful iridescent colouring on some butterflies is also produced by the scales, which in some cases are modified in their structure to cause a breakdown of white light into its various colour components, a process known as refraction. It has also been reported that the scales have a function in improving the butterfly’s flight. The butterflies are divided into two super families, the true butterflies and the skippers. Several more super families, more distantly related, are grouped as the moths. We will not concern ourselves with moths in this manual, their cultural requirements are similar but there are differences. I am often asked why I do not breed moths as well as butterflies, and my reply to this is “There are about fifteen thousand butterfly species, and that is enough to be going on with”. The fact is that even within the butterflies, the difference in cultural requirements of one species from another is just as much as that between say a pig and a sheep, butterfly farming is thus very complex and requires dedication. Too much diversification from the objective is to be avoided if success is to be achieved. A manual of this type can only give broad outlines, and it is necessary for the reader to study his charges and make modifications to general requirements to suit both the species being raised and the operators.

1.2 Anatomy:

One should acquaint oneself with the general anatomy of the butterfly. All butterflies have four wings, a forward pair of larger wings and a rear pair of overlapping rather smaller wings. The body of the adult butterfly consists of the head, the thorax and the abdomen, with a constriction between the head and thorax and thorax and abdomen analogous to our necks and waists. The head (see diagram) has two very large compound eyes, two antennae which are sensory organs that can detect minute quantities of chemicals in the air and a proboscis which is a kind of tube-like organ which is used for sucking liquids for example nectar. When this is not in use it is coiled up in front of the butterfly. The three pairs of legs originate from the thorax. The abdomen contains many of the vital organs, but in particular the ovipositor through which the eggs are laid in the female, and the claspers that hold the female during mating in the case of the male. This is a very simplified description of the anatomy of the butterfly, but it is sufficient for the present.

1.3 Differences between Butterflies and Moths:

The most obvious difference between butterflies and moths is in the antennae. In the case of butterflies they are always club shaped, in moths they are either feather like or tapering to a point. Secondly, when at rest most moths fold there wings backwards in the way of a person clasping hands behind the back, whereas a butterfly closes its wings vertically over the back; some butterflies as the *Hamadryas* do rest with their wings outstretched but never pulled backwards in the method of a moth. There are several other differences some of which are rather technical, but the differences given here should normally be sufficient to separate them.

1.4 The Families of Butterflies:

Butterflies are divided into families of similar characteristics. As more is learnt about butterflies scientists change the classification, but it has at least for the time being settled down into four families; Papilionidae, Pieridae, Nymphalidae and Lycaenidae. In addition there is another family which are not usually regarded as true butterflies, the Hesperiidae. These families are pronounced as Pap-il-ee-on-id-ee, Peer-id-ee, Nim-fal-id-ee, Lie-seen-id-ee and Hes-perry-I-dee.

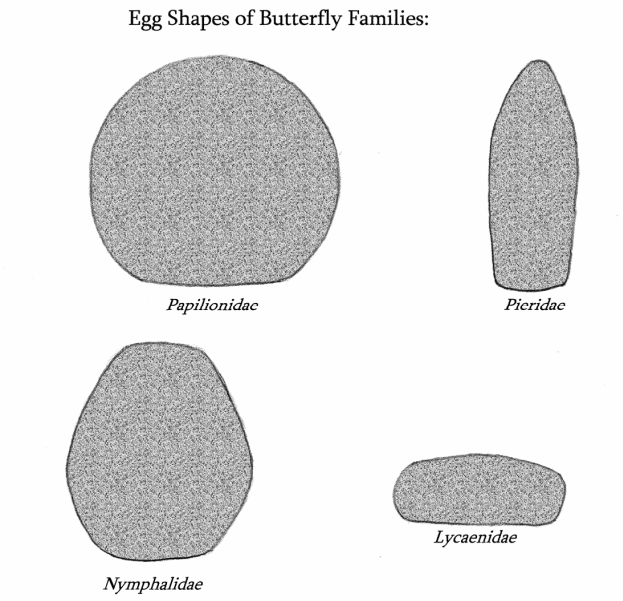
1.5 Origin of Butterflies:

Butterflies have a very ancient origin, probably arising on this earth about 100 million years ago, the first fossil butterflies appearing 48 million years ago and by 38 million years ago the present families were all defined in fossil remains. The first flowering plants appeared 130 million years ago, and as the flowering plants expanded and differentiated into different families so did the butterflies preying on them, so that to this day closely related butterflies feed on closely related plants, and they are almost entirely flowering plants. It is interesting to note that modern man only appeared about 200 thousand years ago, but a tiny fraction of the time that butterflies have been here.

2. The Butterfly Life History:

2.1 The Egg:

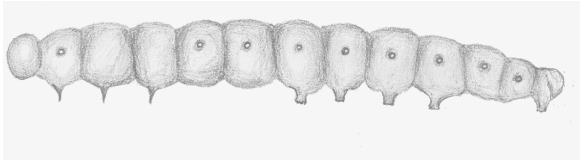
In order to understand the basis of butterfly breeding it is first necessary to know the life history of butterflies, which is rather complicated. The first stage is the egg laid by the female usually about 100 to 500 per female dependant on species and the individual. The egg is normally laid on the food plant of the next stage, the caterpillar. Butterfly eggs are quite small being mostly in the region of ¼mm to 1mm in diameter. Some of the larger Papilionidae lay eggs slightly over 1mm in diameter. The families of butterflies tend to lay typically shaped eggs, the accompanying diagram shows the most usual shapes, the diagram shows the shapes from the side. The texture of the eggs also vary; the Papilionidae are normally smooth or slightly textured, the Pieridae are usually ribbed and cross ribbed, likewise the Nymphalidae, and the Lycaenidae frequently are surfaced with a honeycomb like texture. There are many variations of these textures, some are even covered with spines. The positioning of the eggs also varies with the species, the great majority lay their eggs either singly



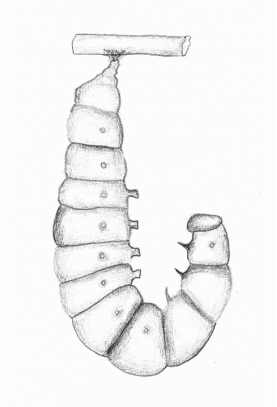
or in batches of up to a hundred, laid rather precisely in rows forming a patch. On the other hand this is not invariable and some species lay in strings, or even heaped together in a pile in a haphazard fashion. Also each species has a favourite place to lay; some lay on the upper surface of the leaf blade, some on the under surface, some on young leaf shoots, some on mature leaves. Some species are very particular and only lay their eggs on the tendrils of plants, and some only on the flowers. It is not possible to itemise all of this information for each species, and even in most cases it is not known. We must rely on observation as each new species is acquired and it is important to train our powers of observation. In a manual of this nature it is only possible to give pointers to show the likely places where eggs may be found.

2.2 The Larva or Caterpillar:

When the egg hatches after usually after about four to eight days the tiny caterpillar that results quite usually, but not always eats the egg shell for its first meal. The caterpillar is also known as the larva, plural larvae. In those species that eat the shell it is important to them, and they may die if deprived of this nutrition. In some temperate species the egg doesn't hatch for some months, but we do not need to concern ourselves with this here. The accompanying illustration shows a very usual form of caterpillar; in fact many are very much more complicated, having wart-like processes or spines. Many are also decorated in a rather complex way; in the case of many swallowtails (Papilionidae) they may be elaborately decorated with a mask like false face, however all exhibit the basic form shown. The caterpillar consists of a head and thirteen segments. The first three segments represent the thorax of the adult butterfly and have a pair of true legs on each; the next ten segments represent the abdomen. Small openings can be seen on the side of the first thoracic segment and the first eight abdominal segments, these are the spiracles, necessary for the caterpillar to absorb air. The caterpillar stage normally lasts for about two to eight weeks in tropical species, but can be up to six months. During this stage the caterpillar eats enormous amounts of leaf. As the caterpillars grow they become too big for their skin, they pause for a while, the skin splits off and they then resume a rapid growth until the next moult. The stage between egg and the first moult and between subsequent moults is known as an instar, and there are several instars between the egg and the pupa; the last stage before the adult butterfly. The number of instars varies in different species, but most commonly five or six. The leaf must be the appropriate

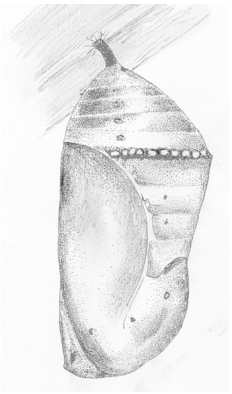


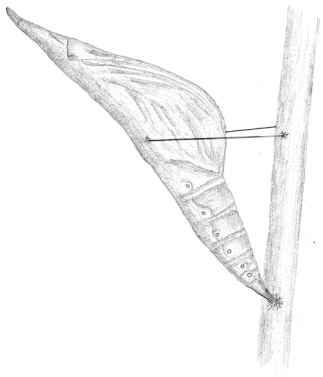
leaf, sometimes only one species, more usually several fairly closely related species and sometimes but quite rarely a very large number of species not closely related. It is quite frequent that different geographical forms of a species concentrate on only one species of food plant, though over the whole range of the species they have a much wider diet. As the caterpillar grows it occasionally sheds its old skin, and then continues growing. The caterpillar then ceases its mobile life, hangs up and forms a pupa. This stage as in the diagram to the left is known as the pre-pupal stage, the pupa results in about one to two days when the pre-pupa sheds its skin, and is covered with a liquid which hardens to form the pupa.



2.3 The Pupa:

Pupae of butterflies come in many different sizes, forms and colours: do not be surprised if your first pupae look nothing like the pupae shown in the diagrams here. Some are brilliantly coloured or embellished with metallic colours, gold and silver, that look exactly like these metals. Though in many cases butterfly pupae are very decorative, their colours usually bear no relationship to the colour of the adult butterfly. As an example, the pupa of *Morpho peleides* is a pure jade green, not at all like the iridescent blue of the emerged butterfly. The pupae come in two types; the first are those that hang, the illustration on the left is of a *Danaus plexippus* pupa, it is suspended by its cremaster that is the stalk like end of the pupa. The cremaster has minute hooks in its end which are anchored on to a silk pad that has been previously spun by the caterpillar on the support. This type of attachment is found in members of the family Nymphalidae. The second type of pupae are those that stand upright supported by a silk band around the 'waist', known as a girdle. The latter belong to members of families *Pieridae* and *Papilionidae*. The pupa of *Dismorphia amphiona* (family *Pieridae*), on the right, is an example of this type of pupa, it stands upright with its girdle attached. Family *Lycanidae* are represented by both types of pupae and also have pupae that pupate in the soil with no hanging support. There follows a period of dormancy when the pupa doesn't eat or move except at times a little wriggle of the abdomen. Already we can





see all the parts of the adult butterfly; the wings the antennae the legs, the head and the abdominal segments, marked as a former on the surface of the pupa. This period may appear to be a dormant period from the outside of the pupa, but internally much is going on; the pupa virtually liquefies, leaving only small germ-like material from which the butterfly constructs itself, and neatly fits into the visible parts of the butterfly that can be seen etched into the surface of the pupal case. The whole process of the staged development from the egg through caterpillar, and this remarkable process within the pupa, to the adult butterfly are known as metamorphosis. In most tropical species the pupal stage lasts about 10 to 16 days.

2.4 Butterfly Hatching or Eclosion:

Butterfly hatching is referred to technically as eclosion. The pupa simply splits open along pre-determined lines and the butterfly emerges. At first when the butterfly hatches you will observe that though the patterning is perfect the wings are miniatures of the fully formed butterfly and are crumpled, they are very delicate at this stage, and if the wings are touched the butterfly will be crippled. Within minutes the wings expand to full size, but they still remain soft and delicate for about two hours. When the butterfly hatches one can view the wings as being something like fine plastic film attached to rubber tubes, the scales already fully formed are attached to the filmy membrane. The butterfly pumps a liquid into the veins that behaves like a resin; it stretches the veins to full size and thereby also stretches the membrane between them, pulling out the scales into final position. Then hardening of the resin-like material occurs and the butterfly is ready to take off. When dry in about two hours, the female normally mates quite quickly and begins to lay eggs in a couple of days. This is a very brief account of the life history of the butterfly; more detail is given in the section of this manual devoted to management of a butterfly breeding unit.

3. Butterfly Farming

3.01 Principles of Butterfly Farming:

Butterfly farming is like any other form of farming, breeding butterflies and selling any surplus not required for replacement stock. A female butterfly usually lays between 80 and 300 eggs dependent on species, occasionally very many more, but it is a general rule that on an average no more than two can survive to maturity, otherwise the species would take over the planet. Under wild conditions the various pests diseases and predators take care of the situation and ensure that a balance is maintained. In butterfly farming we have to try to keep all of these controlling factors at bay so that we can get the greatest multiplication of the butterflies and have a good surplus for sale. In the wild, birds are an important factor in control of butterfly populations. In Belize I have seen the litter of butterfly wings beneath the bough where a jacamar waits on its prey; they destroy an unbelievable number of butterflies. However in the butterfly farm birds are of no problem, they cannot reach the butterflies. Ants are also of great importance in controlling butterfly numbers in the wild, and are also serious pests of the butterfly farm. I have not mentioned diseases which are particularly prevalent under farming conditions, but these and the pests mentioned above are dealt with in more detail under the section on pests and diseases. Butterfly breeding can be carried out on quite a small scale, but if it is intended to embark on commercial breeding, it is essential to start with fairly large breeding facilities.

3.02: Butterfly Farm Buildings:

In setting up a tropical butterfly farm the first requirement is a satisfactory building. One can rear butterflies under very simple conditions, but in order to embark on commercial butterfly production it is necessary to be able to produce them in large numbers, this is only possible with satisfactory rearing facilities. The two essentials are a flight cage for maintaining adult butterflies for egg laying, and a larval rearing house. In due course as the activity expands one may also require ancillary buildings such as an office/packing room, store, and workshop and plant propagation facilities. It is also likely that one may need to establish food plant plantations.

3.03: The Butterfly Flight Cage:

Some butterflies will live, mate and lay eggs in quite small cages, but this is by no means a general rule, and to be safe for virtually all requirements the flight cage should be at least 20 sq. metres in size and 2·30 metres high. The cage should preferably be long and narrow rather than square; that is I favour 2·50 metres wide by 8 metres long rather than 4 metres wide by 5 metres long. Some butterflies seem to be more at home when they can have a long flight path. In a flight cage it is essential to have sufficient shade. Tropical butterflies can not live for very long in direct sunlight, and quickly become dehydrated. It is a good idea to build in some permanent shade into the flight cage, I usually arrange for about 50% of the cage to be roofed with galvanised sheets, preferably in two strips, on a 2·50 by 8 metre cage as above I would put roofs of 2 metre wide by 2·50 long at each end; in this way although there will always be shade, no part of the cage will be in permanent shade, thus the butterflies can always find shade and the plants will get direct sun for at least part of the day. Climatically the other consideration is wind; a cross wind even though very light can be very damaging to butterflies in a cage. A butterfly being very light in weight with a relatively large wing area can in a confined space be dragged against the net, spread-eagled across it, and can either die of dehydration or be severely damaged in its attempts to escape. The best answer to this is to have adequate shrub growth around the cage, or to choose a site for the cage that is surrounded by natural forest or shrub-land. Failing this I find that a *Hibiscus* hedge takes very quickly from cuttings. If none of these alternatives are possible then a wall should be built along the side of the cage facing the prevailing wind. If there is no natural vegetation surrounding the cage but there is a possibility of growing a hedge of *Hibiscus* or other mixed shrubs, then a temporary screen of polythene sheeting may be hung across the windward side of the cage until the hedge is established. The flight cage must be adequately screened with standard sized mosquito screening to keep at least the larger insect pests out of the cage, it will restrict entry to wasps, larger parasitoids and larger ants, but it won't do anything to prevent entry of smaller ants and egg parasitoids; more of this in the section on pests and diseases. The mosquito screening is supported on a base of ½" galvanised wire netting, I prefer the square type, it is stronger and more rigid, but if this is unavailable the hexagonal type of chicken wire is acceptable. A more sophisticated type of flight cage can be used, with a floor raised on concrete posts set in water traps to prevent entry of all types of ants, but in the initial stages it is better to deal with the ant problem as it arises.

3.04: The Larval Rearing House:

The larval rearing house should be about the same size as the flight cage, and it is often convenient to build it attached to the flight cage. It is screened in the same way as the flight cage but is roofed completely. If it is built attached to the flight cage it can have its roof extending half way across the flight cage and this will give adequate shade in the latter. The larval rearing house will be equipped with shelves along one side to take boxes for larval rearing, and with a broad shelf on the opposite side faced with Formica to act as a work table. The rearing house must be adequately screened with standard sized mosquito screening in order to restrict entry of larger parasitoids. Parasitoids are of many types but largely fall into two categories, egg parasitoids and larval parasitoids. These are further described under the section on pests and diseases. This type of rearing house is for box rearing, but it is also possible to rear the larvae on the growing plant in sleeves of mosquito netting, and if this method of rearing is contemplated then a similar sized house with a partial roof will be required for this purpose. Even if this method is used we still require box rearing for the last instar before pupation. The methods are described and compared under the section on rearing.

4. Preparing the Butterfly Farm for Production:

4.1: Preparing the Flight Cage for use:

I usually recommend two flight cages for a start, one for fruit feeding butterflies and one for nectar feeding butterflies, however I will give details of one cage and it will be possible to use this for either type of butterfly or both. Basically the flight cage must provide the butterflies with sustenance, the conditions necessary to mate and suitable food plants for the female butterflies to lay their eggs.

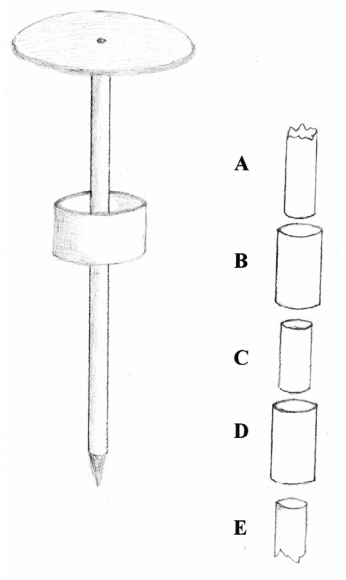
4.2: Adult Food Requirements:

Butterflies may be separated on their adult food requirements; the majority of butterflies feed mainly on nectar of flowers, however, in the tropics about 40% of butterfly species feed mainly on ripe fruit; some but not many will feed on both nectar and fruit, *Hamadryas* is an example. The *Heliconius* butterflies also require pollen, this is collected by the butterflies and stored on the proboscis, where it is later liquefied by an enzyme, and absorbed by the butterfly. This is a very important element in the nutrition of these butterflies and is probably the reason that they

can live so long, up to eight months, which is somewhat of a record among tropical butterflies. There are also other food materials, and butterflies will come to decomposing animal matter, fish, mud puddles, wet cement, decomposing fungi, and many other items. These items probably all contain something required by the butterfly to promote their health, longevity and egg production, but it is doubtful whether it is necessary to include any of them in a commercial butterfly farm.

4.3: Nectar Sources:

The flight cage should contain adequate nectar producing flowers, but not all nectar producing flowers are equally attractive to butterflies. Also, butterflies do not only utilise nectar for its nutritive content; some nectars contain chemicals that are required by the male butterflies to produce their pheromones, which are the scents necessary to make the female receptive to mating. The best way to identify these plants is to observe in the wild and see what flowers the butterflies are visiting. To start the operation it is most important to plant up the pan-tropical species most commonly used; *Lantana*, *Pentas*, *Stachytarpheta*, and *Asclepias curassavica*. Some South American species in the genus *Heliconius* also require pollen, this they mainly get from species of Psiguria and Gurania (members of the Cucumber family). There are also a number of other species from which they can collect pollen, Stachytarpheta is one. A good range of the required nectar plants can be collected in the wild or from plant nurseries, it will probably be necessary to raise some of your own plants from cuttings and seeds. It is quite difficult to maintain adequate flowers in the cage throughout the year, when there are a large number of butterflies in the flight cage, but supplementation by cut flowers standing in bottles of water is helpful, and artificial feeders supplying 10 % sugar solution are useful as a standby. The sugar solution can be supplied on a small platform mounted on an upright stand with an ant trap filled with water at the centre. On the left of the figure the stand is illustrated, it is constructed of ½" PVC pipe, with a 5” diameter circular plywood top, and an ant trap made from a 3" pipe cap in the centre of the upright pipe. The illustration to the right shows the method of insertion of the ant trap; a hole is drilled in the centre of the cap to exactly fit the pipe. It is better to drill this hole slightly smaller than the pipe, and then enlarge it with a piece of sandpaper on round wood until it



is an exact fit. B and D are ½" pipe connection pieces, and piece C should be cut to completely fit inside these two pieces, with the edges of B and D just touching. You can now assemble the ant trap. Fix piece B onto piece C using PVC cement. Next fix on the 3" pipe cap, and finally glue on part D, ensuring that B and D fit closely together over the pipe cap. Pipe A can next be fitted and E to form the base. The top and bottom pipes should have wooden plugs fitted in them, the top cut flush with the pipe and the bottom sharpened to a point to insert in the soil. The plywood top can now be screwed into the top plug with a 1" wood screw. In the case of sugar solution, small tubes with a lip are dropped into holes drilled around the outside of the platform, and these are kept filled with sugar solution. These should ideally be washed and sterilised in 1% Clorox mix every two days, otherwise there will be a build up of yeast which will cause rapid fermentation of the sugar solution. To attract the butterflies small patches of paint can be put around the outside of the hole bearing each tube, but I normally put a large flower such as a single Hibiscus into the tube , having previously cut off the stalk end of the flower.

4.4: Fruit Sources:

The fruit feeding butterflies require the juice of mainly overripe fruit, they particularly like, banana, pineapple, guava and papaya. In general they do not seem to like Citrus fruits, but they do visit a whole range of wild fruits some of which do not appear to be very tasty to us. It is probable that one should provide as large a range as possible, as I assume that perhaps the pheromones of these species are derived from some of these fruits. The fruit should be placed on a saucer or plastic plate on top of an ant proof platform, as described under nectar sources, having first cut open the fruit to expose the juice.

4.5: Pheromone Producing Plants:

Butterflies are controlled by chemical scents or pheromones. Males produce quantities of pheromones which they use in making the females receptive to mating. In some species the required pheromones cannot be produced unless the male has access to certain flowering plants from which they can collect the necessary chemicals to manufacture them. These are particularly important in the ‘Danaid’ butterflies, and mostly belong to family Verbenaceae (Lantana, Stachytarpheta) and Boraginaceae (Heliotropium). The best safeguard is to keep a large range of butterfly visited flowers in the flight cage.

4.6: Larval Food Plants:

In the early stages it is useful to keep a good range of likely larval food plants within the flight cage, to determine which plants are favoured for egg laying by the female. Later on for reasons that I will describe later it is probably not a good idea to keep the food plants in the cage continually. Unless we have a suitable butterfly food plant the butterfly simply will not lay its eggs. In starting a new species it is vital to have a suitable range of plants in the flight cage. One cannot deceive the butterfly into laying its eggs on the wrong plant, it is equipped with sensors on its forelegs with which it can determine exactly the species of plant required. Larvae of butterflies quite often only feed on a few closely related species of plants or sometimes only one, completely ignoring other species. A smaller number of butterflies are generalists, feeding on a great range of plants. It is also quite common for a butterfly to feed on one species in one area and a completely different one in another area. Closely related butterflies tend to feed on closely related food plants, thus for example the species of *Heliconius* all feed on *Passifloras*, but usually only on a few of them. This is a useful guide when trying to find the food plant of a new species that one is attempting to breed. Another useful way of finding the food plant species is to go to an area where the butterfly species is common and observe butterflies that are "drumming". The butterfly is obviously not nectaring for it is mainly settling for brief moments on leaves, when on close examination it is seen to "drum" on the leaf with its forelegs. The tips of the forelegs are equipped with chemo-receptors which can detect traces of chemicals that indicate that this is, or is not a leaf that could support its caterpillars. Such butterflies are thus very helpful in tracking down the food plant if you wish to go into large scale production of a species, for once the butterfly has found the plant it will start egg laying. The most trouble free way of finding the food plant is within a rural area, to explain to a young person how to observe when a butterfly is laying, go to an area where the butterfly is common, and leave it with him. I have used this system in various parts of the World, and find in general that within about forty eight hours I am in possession of leaves with eggs on them. The second more laborious method is to track down the likely species in various butterfly publications. In many cases the actual species may not be known but there are usually guidelines as to the family or even Genus which is useful, but at this stage you may probably have to get the assistance of a good field botanist to help you locate the plant. This first stage can be most easily accomplished by consulting the **CATERPILLAR HOSTPLANTS DATA BASE** of the Natural History Museum, London on web

site: www.nhm.ac.uk/research-curation/projects/hostplants/ click on SEARCH THE DATABASE and you will be able to get a comprehensive view of food plants of butterflies. You can enter by Genus or Genus and Species, and get the known results. However, we are still lacking knowledge of many species. If you get no results from a species then check on the Genus and see what related butterflies are feeding on. To assist you, as an example, in the case of butterfly *Morpho peleides*, *Morpho* is the Genus and *peleides* is the Species.

5. Obtaining the Breeding Stock:

5.1: General:

It is sometimes possible to get the initial breeding stock from other breeders, this is sometimes the simplest method, but is not very satisfactory, as one doesn't know the exact provenance of the stock. From the ethical and scientific point of view, the breeding stock should be obtained within reasonably close proximity to the area of the breeding farm, and at a similar altitudinal level. For this purpose, I would suggest that within 200kms and 1,000 m altitudinal range might be reasonable.

5.2: Stage of Butterfly to start from:

One can start from any stage of the butterfly, but adult butterfly collection is preferable though there may be some cases where collection of the early stages is desirable. With some species that lay copious eggs on a known food plant, the egg can be quite a good way to start, however this is not always so easy because in most cases the correct food plant for the area is not known, and in any case it may be a tree or high growing vine with the eggs being laid high up and out of reach. When the food plant is low growing the caterpillar may be a good starting point, but caterpillars have the disadvantage that they can be heavily parasitized and care must be taken not to introduce parasitoids into the breeding cages. There is little doubt that the best way is to collect adult female butterflies. The vast majority of female butterflies collected in the wild will have already mated, and so long as a suitable food plant is available will lay eggs.

5.3: Catching a Butterfly:

There are basically two methods of catching the butterfly, with a net, or with a trap. Catching a butterfly with a net involves some skill, and one needs to learn the different methods. These are best learnt by practice,

but a few suggestions might be helpful; one does not chase after the butterfly with the net held high above the head, but rather wait at a suitable vantage point close to a nectar plant and choose the moment with a deft sweep of the net to capture a butterfly. Once caught the butterfly should be carefully taken out of the net with the wings folded, holding it between thumb and forefinger so that all four wings are held together. Be careful not to pull the butterfly away from the net sharply, the tiny claws on the end of the legs can easily become entangled in the net, and it can lose a leg. A butterfly without forelegs is useless for breeding, as since the sensory organs for locating food plants are on the tips of the forelegs, it cannot find the food plant without them. Otherwise for fruit feeding species, and those species that will come to bait of various types, the trap is a better alternative. This consists of a cylinder of mosquito gauze suspended above a platform on which a plate of bait is placed. The butterfly comes to the bait and when disturbed flies towards the top of the trap. These traps may easily be constructed, but they are not very efficient as the butterfly sometimes escapes. A much more efficient trap is a later invention, and has an internal cone that acts as in a lobster pot. In this trap, when disturbed the butterfly flies up inside the cone, then when left alone it comes down again, and becomes trapped between the cone and the butterfly net. These traps are rather difficult to construct, but can be purchased from good entomological dealers. The type of bait used in these traps is usually of two sorts, fruit and decomposing fish. I find that ripe bananas fermented for twenty four hours in a closed tin or plastic box or prawns cut down the centre and kept in a sealed box for a couple of days are best for this, but they should not be used together. Different species will come to the two types of bait.

5.4: Transporting Live Butterflies:

If you are travelling some distance to the farm, the butterflies should be secured one by one in paper envelopes, preferably the type known as glassine; they should then be put in a small cold store box, the type made for carrying cold canned drinks. The box should previously be prepared by putting some ice packs in the bottom and making a wire net platform that will hold the butterflies away from the ice packs. In this way the butterflies will be cool enough to remain dormant until they reach their destination.

6. Butterfly Production:

6.1: Density of Butterflies in Flight Cage:

Butterflies may be kept quite densely in their flight cages, for instance in Belize in one cage we have about 3,000 flying continually in a cage 12m X 3·70m X 2·15m high, that is about thirty per cubic metre. However this cage is purely one species. I have found where two species are kept together and one is in much lower numbers than the other, that sometimes that species does not mate and/or produce fertile eggs. All male butterflies produce scents, known as pheromones that attract the female of the species. I assume that when another species is present in a very high density, the level of pheromones of that species is so high that it inhibits identification of the specific pheromone in the lesser species. Once one has large numbers of a species it is necessary to have a separate cage in order to maximise production. Butterfly numbers in colonies fluctuate and in my experience one can not really expect that one has a permanent colony until one has at least 100 butterflies of the species flying on a regular basis. Of course some species of butterflies are seasonal and are absent as adults for quite long periods.

6.2: Egg Production from Flight Cage:

I normally recommend two flight cages as a minimum, one for fruit feeders and one for flower feeders. The larval food plant should never be kept in the flight cage for the whole twenty four hours once commercial production has started, unless one has an extra flight cage that can contain all known food plants or potential food plants when seeking out the favoured food plant of a newly acquired species. Eggs should be collected at least daily, and more frequently if there is an ant problem. Eggs from each day's collection for each species should be put in a labelled clear polystyrene box. If these are unobtainable, small plastic ice cream tubs with a cellophane or cling film top, secured with an elastic band will be satisfactory. After four days, a piece of the food plant should be put inside, and this should be changed daily until the small caterpillars emerge and transfer themselves onto the leaf. This is only a guide, in some species the eggs will hatch in less than four days, so for your first batch of a new species you will have to watch carefully, if there is a change in egg colour then put the fresh leaf in. If the change of colour is accompanied by a shrinking or collapse of the eggs, then this is due to infertility, and you will have to start again. If you put the fresh

leaf in too soon, the leaf will be dried out and be useless by the time that the caterpillars hatch; in addition the drying out will cause condensation inside the box, which may lead to mould formation and death of the eggs. There may be need to carry out egg surface sterilisation in the event of serious bacterial infection of the stock. This is referred to in a later section of this manual.

6.3: Rearing Caterpillars General:

Caterpillars of butterflies vary tremendously in their requirements, and they may be reared by several methods, and all of these methods have advantages and disadvantages and what may suit one species is not at all suitable for another. Some of the characteristics that may influence one in choosing a system are; size of the caterpillar; behaviour of the caterpillar that is naturally solitary or gregarious; type of food plant, a tree, a vine or a herb; type of leaf, resistant or not to wilting and desiccation; degree of cannibalism and many other factors. In this manual I will describe box rearing and sleeve rearing, and some of the variations of these.

7. Box Rearing:

7.1: Box Rearing General:

Breeders often start with rearing butterfly caterpillars in small containers for example ice cream tubs, sealed by paper tops, secured by elastic bands. This is effective but is extremely labour intensive. Butterfly caterpillars are often very selective about the food that they eat even if presented with the right species. In the Philippines I found two species a *Eurema* and a *Charaxes* that both fed on the same food-plant a small Leguminous tree, the *Eurema* fed on the young leaves and the *Charaxes* at all stages only fed on the mature leaves. I can well imagine that if they were box fed using leaves of the wrong maturity, they would not survive. In small boxes larvae often only get two or three leaves, if none of these are to their liking they will fast until the next supply of fresh leaf, fasting in caterpillars hastens their speed of development towards pupae with a resultant undersize pupae. Some species of butterfly are cannibalistic at some stages, and these species can only be satisfactorily reared in confinement. In these species unless they are very desirable, it is probably better to avoid them, or opt for the sleeving method of production.

7.2: Type of Box:

It is important that the type of box used can be sealed properly and quickly. I mainly use two types of box, plastic boxes with clip down lids, and wooden boxes made from plywood; the wooden boxes are equipped with metal clips that hold the lid down, and the top edges have strips of foam rubber glued on to make a good seal. It is essential that the boxes used can be easily sterilised between batches of caterpillars, this is carried out using 1% Clorox swabbed on with a household sponge and then rinsed with clean water. In the case of the wooden boxes, they need to be coated with a good quality varnish in order to be moisture resistant; this makes for a very high cost of maintenance. The plastic boxes have the disadvantage that condensation on the sides can be serious and present a hazard to small caterpillars which may get stuck to the side or even drowned. I favour the plastic boxes as being cheaper and easier to maintain.

7.3: Box Ventilation:

In both types of box ventilation must be given, and I normally compromise at making holes equal to 25% of the lid area, and covering these holes with mosquito gauze glued on. If you have too much ventilation you run the risk of dehydrating the foliage, so there is a delicate balance to get the ventilation right. Unfortunately because of seasonal changes in temperature it will never be possible to get things completely right for all occasions.

7.4: Size of Boxes:

Considering the size of boxes, the larger the boxes the cheaper the cost of rearing per caterpillar, but also one has to consider that should disease get into your stock the bigger the losses. I suggest that the largest boxes that should be considered would be in the region of 60cm long by 40cm wide by 30cm high or about 70 litres capacity. Utilising this size box and putting the whole day's production of young larvae into one box one should be able to maintain a production of about 105 marketable pupae per day from larger butterflies. It may be reasonable to expect a production of 1·5 marketable pupae per litre of box per day, from larger species and four or five times this production from smaller species. I consider that it is not really worthwhile to aim at a production of less than a hundred a week marketable pupae of any species, so that the smallest size useful box on this basis would be about two litres capacity, say 9cm

by 11cm by 20cm. For larger species one would need ten litre boxes to maintain this production.

7.5: Water Supply:

When dealing with the smallest size caterpillars, that often require young leaves, it is sometimes necessary to provide them with food plant in water. For this purpose the cuttings are placed in the type of tube used by florists, plastic tubes fitted with rubber caps through which the stalk is inserted. It is preferable to design some kind of support to hold the tube vertically, either a small wooden box with holes bored in it or a frame of wire netting.

7.6: Putting the Young Caterpillars into the Boxes:

The young caterpillars from one day's production of eggs are removed from the plastic hatching box on their leaf and put into a rearing box with a supply of fresh leaf. There is no need to move the caterpillars onto the leaf they will find their own way over. You may underestimate the size of box required, so you will have to experiment in the early stages to find the ideal size.

7.7: Handling of Caterpillars:

Caterpillars should never be handled with the fingers; this is neither good for the caterpillars or the handler! For the caterpillars, pressure on the body is not good, and there is also the danger of transferring disease by hand from caterpillar to caterpillar. For the handler there is the possibility of getting dermatitis, a persistent inflammation of the hands. Not all caterpillars cause this, but the more that you handle them, the more danger there is of getting it. The boxes should be cleaned out every day. For this purpose one requires a Formica covered table or a heavily varnished table, something that can be kept very clean and sterilised. The box is turned upside down on the table and knocked out. You might see some caterpillars adhering to the side of the box; leave them. Pick out any loose pieces of leaf that haven't dropped out, put in fresh leaf sufficient for the next 24 hours (You will soon learn how much is required, but you should ensure that at least a half is left over when you open the box on the following day). Now put the caterpillars back in, if they are on leaves you can restrict the amount of old leaf by cutting away with scissors and then drop into the box again. If they have crawled off the leaf, coax them back onto a fresh leaf and put it back into the box. Many breeders use a small brush for transference of caterpillars, I do not

do this because I consider the continual use of one brush on many caterpillars is too dangerously lacking in hygiene; far better use a clean leaf for each caterpillar. Once satisfied that all of the caterpillars have been put back into the box, it should be closed down. Brush up the rubbish, dead leaves and frass (that is the caterpillar droppings) and put it into a bucket kept for the purpose, then swab the table with a sponge dipped in hypochlorite solution (Diluted Clorox, 1 part to 100 parts of water). Now proceed to the next box. When a box is empty it should be thoroughly cleaned and sterilised, use clean water for washing and finally swab with a sterilising solution on a sponge. For sterilising containers and work surfaces use Sodium hypochlorite solution Clorox at one part of the concentrated fluid to 100 parts of water, which is about 140 mls in a standard sized bucket. Be careful with this mix it will bleach if splashed on your clothes.

7.8: Advantages of Large Box Rearing:

In box rearing a number of young caterpillars are put in one box and fed with a daily amount of the food plant. It must always be remembered that the caterpillar has no source of moisture apart from that contained in its food. If the leaf is not freshly picked, or if it is not very succulent it may quickly dry out, preventing the caterpillar utilising it because of its low water content. Some caterpillars are normally gregarious feeders in the wild, others solitary. It would seem that the gregarious feeders would be happy to be in large numbers in a box and the solitary feeders in small numbers. However, this is not always the case. In one species, normally a solitary feeder; when packed in large numbers in a box, do attempt to escape, but if the box is completely proof against escape, they do perfectly well. It is natural for the solitary feeding caterpillars to seek to be alone, and this undoubtedly gives them a survival advantage in the wild; but, in captive systems with adequate fresh food supplied and predators excluded, they do extremely well when confined in a small space. Keeping 100 caterpillars in 100 boxes, is infinitely more expensive in labour than keeping 100 caterpillars in one large box. It also has an advantage in that in the wild the caterpillars may choose its leaf, whereas in a small box if for any reason it doesn't like the one or two leaves included, it will fast, bringing on an early move towards pupation, resulting in a small pupa. In large boxes they have much better choice and large pupae result.

8: Sleeve Rearing:

8.1: Type of Sleeve:

There are several possible variations of sleeve rearing, but in all cases it consists of covering the whole or part of a plant with a tube of netting usually made of mosquito netting or a similar type of cloth gauze. The holes in the netting or gauze must be small enough to prevent the escape of the smallest caterpillars, and to prevent the entry of smaller predators, such as wasps, spiders, praying mantis etc, and also the larger ants and larval parasitoids (parasitic wasps and flies). I prefer a dark coloured material for this, as it is easier to look inside the net through dark material than white. The net should be soft, so that it will easily fall around the leaves, and the apertures should not be so fine that they severely restrict air movement. The net is best equipped with a wide hem at top and bottom, with a draw string, so that the sleeve may be fixed tightly around the plant or plant pot at the base and tied securely at the top. The sleeve may be fixed on to a complete growing plant, tied around the bottom to include the stem, or it may be used for covering a potted food plant, in which case the sleeve can be secured around the pot rim. For large plants, trees and shrubs, where a sleeve to cover the whole plant would be impracticable, it is possible to sleeve a small branch, once again tying the base securely around the branch. One should note that in this system it is perfectly possible for a larval parasitoid to inject its eggs through the netting onto a caterpillar feeding close to the net; it may be preferable to have the sleeves further enclosed within a mosquito screened cage if the species of butterfly being reared is particularly prone to larval parasitoid attack. The net can be provided with a zip or Velcro fastening down one side for improved access, but in general I consider this to be an unnecessary refinement, as by the system that I describe the net only has to be opened twice, once to put the young caterpillars in, and once to take them out, to box up ready for pupation.

8.2: Seeding the Sleeve with Young Caterpillars:

It is possible to put eggs directly into the sleeve, but I prefer to put the young caterpillars in, having hatched them in a small polystyrene box. The day after hatching when the caterpillars are on a fresh leaf is a good time to transfer them. The leaf with the caterpillars on it may be transferred to the chosen plant by clipping the leaf onto the plant with a paper clip. It is important to assess the number of caterpillars that can be put in a sleeve, this is best done by first of all box rearing a batch of caterpillars and then making a calculated guess at the number of

caterpillars that the plant enclosed by the sleeve could support to maturity. One should aim at the caterpillars eating about 50% of the leaf by maturity. There is no easy rule of thumb; you can only learn this by experience. Keep to lower numbers at first, and increase in later batches until you get the perfect number.

8.3: Rearing the Caterpillars in the Sleeve:

This is a labour saving method; little needs to be done until the caterpillars are removed from the sleeve. They should be observed daily to check that all is well, and when they have reached the last instar, they should be removed from the sleeve. Once again you can only learn the right stage by experience, but it would be helpful to box rear at first to observe changes in the caterpillars when they are approaching pupation, sometimes there is a distinct change in colour. When this stage is reached in the sleeve, then it is time to box up, putting the caterpillars into the box with cut leaves. For a day or two the caterpillars will carry on feeding, but then you will observe further changes, some caterpillars will cease feeding, and become slightly shrunken in appearance. At this stage they should be put in a separate box with sticks that they can pupate on, these should be small sticks that can be wedged across the box near to the top. You should also put a few food plant leaves in the box in case you have misjudged the correct time. It is always advisable to separate the caterpillars off at this stage; otherwise the other caterpillars that are still eating might take an indecent interest in the pupating caterpillars, causing them to become deformed pupae. They might even attack them, and devour them, something that sometimes happens with many species, even those that are not normally cannibalistic.

8.4: Box Rearing or Sleeving?:

I now consider that the large box rearing method is the most satisfactory method of production for all species that are not cannibalistic, though for smaller production numbers in case of smaller species on suitable food plants the sleeving method could vie with this. The sleeving method does appear to produce better quality pupae in most cases, and certainly a higher proportion of larvae pupating. I consider that anything less than 100 pupae of any one species a week is not really a viable proposition.

9: Maintenance of Food Plant Supply in Good Condition:

9.1: Effects of Shortage of Leaf or Poor Quality:

In captivity, and presumably in the wild as well, butterfly caterpillars will sometimes skip a moult when their food is in short supply and produce a small pupa. This is something to be guarded against, as these small pupae are not saleable, neither are they very satisfactory for breeding purposes. When a moult is about to take place, a caterpillar will fix itself to the side of the container or a leaf, by hooking itself into a silk pad of its own spinning. At this stage no attempt must be made to move the caterpillar from where it is attached, it is very delicate and any attempt to move it will result in its death. One must learn to be a good observer for abnormal conditions. Usually the frass (that is what we call the droppings) are fairly dry and solid. However, sometimes the frass can become wetter akin to diarrhoea, and this can be caused by three possibilities; a nutritional disorder, a disease or the stage of development of the caterpillar. It is said by some breeders that caterpillars will develop diarrhoea if fed on cut food plant kept in a container of water; I believe that this is all connected with the water intake of the caterpillar and is not in itself a serious condition. The caterpillar cannot control the percentage water in its food plant; neither can it take water from any other source than from its food plant. In the case of food plant standing in water, in some species it may well be that this raises the water percentage to too high a level, and the caterpillar is oversupplied with water causing a loose frass. I believe that the caterpillar can control this in the wild by choosing its leaf. The condition is not harmful in itself, but if allowed to go on unattended to, can be instrumental in causing an outbreak of a bacterial disease. In boxed caterpillars the same problem can arise by inadequate ventilation of the boxes or the feeding of wet food. An outbreak of a bacterial disease must be avoided at all costs, and good management is the best protection. Sometimes when a caterpillar moults the new instar is a different colour, and often this is quite a dramatic change in colour.

9.2: Food Plant Supply for Larger Production:

When the production of a species is rising, sooner or later one will have to decide how the food plant supply will be maintained. In some cases where the food plant is very common, it may be possible to gather it in the neighbouring forest land, but even where it is common it may not be possible to do this. If the food plant is a tree, it may be impossible to harvest, or an annual plant may die off in the dry season and will only be possible to maintain by irrigation. One sometimes is faced with a

decision as to which is the best food plant among several contenders. The leaf may vary in quality, and if box rearing is intended, a thicker leaf is preferable to a thinner leaf that will wilt quickly and dry out. In the end it may be necessary to start a plantation to produce sufficient leaf, there are pitfalls to this. Even among crop plants the methods of production are innumerable, when dealing with a butterfly food plant it has in all probability never been grown in cultivation before and there are no guidelines. Sometimes when grown on a large scale the food plant may be attacked by a pest species and decimated, under such circumstances the only possibility is to grow the food plant in a screened cage, in this case to keep the butterflies out rather than keep the butterflies in!

10: The Pre-Pupal Stage:

10.1: Signs of entering the Pre-Pupal Stage:

After the last moult in the caterpillar stage, the caterpillar enters on its last instar prior to pupation. Eventually changes in the caterpillar become obvious; it voids a rather large quantity of fairly wet frass, and becomes rather shrunken in appearance. At this stage it sometimes changes in colour and stops eating. One must learn to detect this stage for each of the butterfly species being bred.

10.2: Dealing with Pre-Pupal Larvae:

When box reared they should be separated off from the other caterpillars at this stage, and put in a separate box. It is alright to put these caterpillars together but they should not be mixed with those still eating. This stage of the caterpillar is known as the pre-pupal stage, and the caterpillar will soon hang up and turn into a pupa, this is when they are very vulnerable to attack by other caterpillars even though the species is not a particularly cannibalistic one. When rearing in sleeves the caterpillars should be removed to boxes in the last instar, and again be separated when they reach the pre-pupal stage. Apart from avoiding destruction of the pupa by other caterpillars, this also enables an accurate date of pupation to be recorded, which is most essential for sale purposes.

11: The Pupa:

11.1: Pupae General:

For the purpose of butterfly breeding we have to particularly consider, the method of attachment of the pupa to its support. When the caterpillar hangs up to go onto the pupal stage (we call this the pre-pupal stage), it fastens itself by a little pad of silk. Normally a pre-pupa will form a pupa within about 48 hours, and its shell is hard enough to allow of it being removed after another 24 hours.

11.2: Treatment of Pupae that Pupate in Hanging Position:

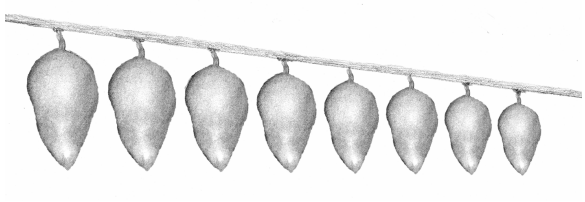
In the case of butterflies that pupate in the hanging position, it is necessary to find the edge of the silk by scraping with a pin or a sharp piece of wood close to where the pupa is attached. When an end is found it may be gently pulled, and the whole pupa will come away from the base. On no account must the pupa be removed by pulling the whole pupa, this might well result in the death of the pupa.

11.3: Treatment of Pupae that Pupate in Standing Position:

In butterflies that pupate in the standing position, the girdle should be cut with a small sharp pair of scissors, before scraping the silk pad from the base of the pupa and removing it from its support. It is necessary to cut the girdle on both sides, since it is connected both to the support and the pupa. On no account attempt to break the silk waist band, it is very strong and will sever the pupa if any pressure is put upon it, resulting in its death.

11.4: Hanging Pupae:

The pupae are suspended from a stick, being attached by a small drop of contact adhesive at the cremaster. The contact adhesive can be set at about 4 centimetres apart on a stick, and as it is drying the pupae can be gently pushed into the adhesive and left lying down for 10 to 15 minutes until the adhesive is dry. The stick can then be hung up in a suitable place in the flight cage to await hatching of the adult butterfly. The illustration is of Morpho peleides pupae. The stick should be hung in a light place but out of the direct rays of the sun, the pupae



hatch in most tropical species in about 10 to 16 days. At first when the butterfly hatches you will observe that though the patterning is perfect the wings are miniatures of the fully formed butterfly and are crumpled, they are very delicate at this stage, and if the wings are touched the butterfly will be crippled. Within minutes the wings expand to full size, but they still remain soft and delicate for about two hours. No attempt should be made to touch them at this stage until they fly off of their own volition. At this stage the wings are strong.

12: Pests and Diseases:

12.1: General:

The pests and diseases of butterflies are innumerable, and we can only touch on the worst here. In a species of butterfly laying 100 eggs with 12 generations a year, if every egg produced a mature butterfly we would in the course of a year have 50 billion, billion butterflies from the original pair. The reason that butterflies have such a capacity for multiplication is because of the multiplicity of control agents that exist. If the egg production was much less the species would die out. Firstly there are the larger predators, birds, lizards, small mammals for example rats and opossums and monkeys. Many of the species of these groups have a partiality for butterflies at all stages, some butterflies are quite toxic, they either take in their toxins in the food plant or possibly sometimes synthesize them. This doesn't mean that the butterfly is safe from attack for there are many other pests and diseases waiting to take over. In the butterfly breeding unit this type of predator is not very serious because they are excluded by the wire netting. Next come the smaller predators; spiders, scorpions, praying mantids, but worst of all ants. Ants come in hundreds of species, some are harmless, others are very carnivorous and will attack all stages of the butterfly. They will carry off the eggs soon after they are laid, attack the caterpillars and pupae and even immobilise the adult butterfly when it is temporarily resting on the ground and devour it. Size is immaterial, even some minute species of ant can devour a whole pupa in record time by simply calling in their friends and attacking in hundreds. Some butterflies appear to be immune to species of ants that may attack other butterflies. I have found that *Morpho peleides* is not attacked by a species of ant that lives inside the stem of its food plant *Platymiscium yucatanensis* yet this ant appears to destroy other insect pests that attack the tree. I have also noted that once when we had an invasion by a column of army ants, though they destroyed spiders and scorpions and many other undesirable creatures they completely avoided

Caligo and *Morpho* larvae and pupae. One should not take it for granted that these or any other species of butterfly are always immune to attack by these voracious creatures. In butterfly farming when such creatures as birds and ants are controlled, bacteria and viruses become more serious pests, but luckily they can normally be kept at bay by good management. Parasitoids which attack the eggs and the larvae are also serious pests and can multiply to huge numbers in the artificial conditions of a butterfly farm.

12.2: Parasitoids:

It is likely that the reader will not be conversant with the term parasitoid; a parasite does not usually kill its host, so the term parasitoid was coined to cover parasitism where the organism almost invariably kills its host, as in the case of parasitoids of butterflies. There are two types of larval parasite: wasps and flies. Some are quite large, about the size of a house fly and are easily excluded in numbers by the fly screening in the cages, in any case caterpillars are normally raised either in plastic boxes or in sleeves, so in both cases, should a solitary female parasitoid find its way into the cage it will have great difficulty in reaching its host. One should always be on the look out for these larger parasitoids, but I have found that in the methods of rearing described they are rarely a problem. In the case of the egg parasitoids, they are so small that it is almost impossible to keep them out of the breeding unit. The egg parasitoids are all minute wasps. The larval parasitoids are normally too large to pass through mosquito netting that is why we usually clad the butterfly houses with mosquito netting. The egg parasitoids are laid in the egg, and from my own observation I have found that they egg take about twice as long as the butterfly caterpillars to hatch. Thus if the butterfly caterpillars hatch in five days then the parasitoids normally hatch in about ten days. You will not see them hatch for they are minute; often times the total length will be about half a millimetre. If you have a big problem with large numbers of eggs not hatching, then suspect egg parasitoids. To prove the point put a number of eggs with the larval food plant in a sealed clear polystyrene box. When some of the eggs hatch and the caterpillars migrate on to the food plant, remove the leaves, leaving the remaining eggs in the box. If you have egg parasitoids, then you will observe them in a few days as tiny black dots on the underside of the lid. If their presence is proved then preventative measures must be taken.

12.3: Controlling Egg Parasitoids:

Most butterflies are not too affected by egg parasitoids when bred in small numbers, but butterfly farms can become infested with them

because of the numbers and density of available host eggs. In the Philippines I observed that up to about 95% of the eggs of *Papilio alphenor* could be attacked by parasitoids when egg laying was carried out in sleeves with a very high density of butterflies and eggs. Mosquito gauze will not protect against these pests, for the holes easily allow their entrance, and any fabric with holes small enough to prevent their entrance, will restrict air flow and cause excessive heating. but I have found that the parasitoids home in on the food plant of their host. I found in Thailand that a parasitoid attacking Citrus feeding butterflies would assemble on Citrus in the early evening resting individually on young shoots, in readiness for the morning egg laying. I have found that the most effective way of dealing with these creatures is to only hang the food plant up in the cages at the time of the day when they are laying; so with most butterflies we hang it up at about 8 am and remove it at about 3 pm. The majority of tropical butterflies are most active during the middle part of the day, from around 9 am to 3 pm, however, some groups notably the Caligo's in South and Central America, and other groups in Africa and Asia tend to be only active at dawn and dusk. This affects the way that we deal with them for egg laying. Ensure that no food plant is in the cage for much of the 24 hours: 4 pm to 8 am in the case of butterflies that lay their eggs during the day time, and 8 am to 4 pm in the case of butterflies that lay their eggs early in the morning or late evening. Empty all egg boxes into a disinfectant bucket immediately after removing freshly hatched butterfly caterpillars to ensure that large numbers of egg parasitoids are not produced in the cages or in their vicinity. If this does not work out for you for the particular species that you are breeding, then you could try the method of laying in a box. For this you need a small plastic box about 10 cm cube. The method is to mark the female with a small spot of nail varnish on the underside of the females wing when you see a pair mating. Next when the mating is finished you have to keep an eye out for the marked butterfly and confine it in the box with its food plant, covering the bottom and sides of the box with the food plant, even possibly the top, with the leaves held in place by scotch tape. The box should be kept in a light place but out of the direct rays of the sun. The butterfly has to be taken out of the box daily and force fed to capacity. Some butterflies lay only a maximum of about ten eggs daily, others lay a whole batch in one day. This system is too labour intensive for the former kind but can be useful for the second. I have found it very useful for *Hamadryas* species which are often very heavily parasitized. Some species have their own protective measures against egg parasitoids, which ensure that they only have a low level of attack. I have found that *Ariadne ariadne* has a spine covered egg, when it is laid the spines are

pressed close to the side of the egg, but they open out giving complete protection to egg parasitoids within two minutes.

12.4: Diseases:

Diseases include bacteria, viruses, fungi and nematodes; of these under normal conditions bacteria and viruses are the most important. Bacterial diseases cause the death of the caterpillar, usually coupled with a blackening of the body, and exudation of a foul smelling liquid. With virus infections the caterpillar normally dies without any obvious symptoms. I consider that with diseases the best method is prevention, and if a good system of rearing is maintained and hygiene is attended to you should rarely have serious problems. One must attend to adequate food supply in a sufficiently fresh state, maintainence of a satisfactory humidity level to ensure that the humidity does not fall too low which will cause early wilting of the food plant or rise too high which will result in condensation of water in the box and resulting mildew. The caterpillars also require shelter from the sun and a fairly constant temperature. All boxes must be attended to every day and above all the caterpillars must not be touched. When all of these matters are attended to you will still occasionally get disease outbreaks. The most obvious danger is in the import of fresh wild stock into the cages. When a stock has been multiplied to a good level, it is advisable to isolate it from other stock by keeping it in its own cage, and maintaining it in an isolated state without more stock being imported.

12.5: Egg Surface Sterilisation:

The most important protection to the stock from disease is egg surface sterilisation. When the egg is laid by the female butterfly it has on its surface spores of diseases transmitted by the butterfly, these are ingested by the young caterpillar in its first meal and thus infect the caterpillar at its most vulnerable stage. In surface egg sterilisation the eggs are soaked for a short period in a 0·1% sodium hypochlorite solution, this is the active ingredient in commercial bleach such as “Chlorox” this can be obtained easily in most countries, but I find that the tablets used for sterilising baby bottles are much more convenient. The tablets that I use contain 800mg of the active ingredient Sodium dichloro-iso-cyanate and I use one tablet dissolved in 750mls of water. Alternatively one could use commercial bleach, this quite usually contains 5·5% sodium hypochlorite, (the concentration will be given on the bottle) and at this concentration one would need to use 10ml in 540ml of water. In this case you would need to be accurate in your measurement. The eggs are soaked for 5

minutes in this mix and are then rinsed in fresh water and dried on some absorbent paper. The water used for rinsing should be clean drinking water, if you are at all doubtful, water that has been boiled and cooled should be used. During this process the surface of the egg is slightly dissolved away, if the sterilising solution is too strong or the time in the solution is too long the egg will be killed. It will be necessary to experiment a little with this on using the technique with a new species, always use the strength of solution as indicated above, and start by soaking a small number of eggs, say ten for five minutes. If these give a good hatch you can leave the method like this if not try another batch reducing the time in the solution by one minute.

12.6: Pests:

The small mammals lizards, birds and so on are easily controlled by maintaining a good wire mesh cover to the cages and making sure that they are adequately maintained. The mosquito gauze will prevent ingress of large social wasps which can be very troublesome and will carry off adult butterflies, normally first cutting off the wings and then carrying off the body. Wasps can cut their way through plastic mosquito gauze if they are determined enough, but it is usually a safeguard, but keep watch and repair quickly when necessary. Ants can be very troublesome, they work quickly and efficiently. Effective measures to prevent ingress of ants are expensive, and include building the cage on a concrete raft with a water filled moat around the outer edge, or raising the whole building off the ground on concrete stilts with water filled ant traps at the base of, and around each post. This can be very cost effective when the production is high and there is an assured market, but otherwise one is better not to introduce these measures at first, but tackle the problem as it comes up. Insecticides and butterfly farms do not make a likely partnership, but sometimes a limited amount of insecticide use is necessary. It can be very effective in diverting columns of army ants, but this can also be done by spraying a little diesel across the path ahead, and this is much less dangerous. When ants are entering the building from outside, a little insecticide sprayed at the foot of the building outside can be a very good deterrent, but make sure that no drifting spray enters the building or pollutes a potential food plant source. Make sure that any insecticide used is bio-degradable with a short life. Where some of the small ants get settled inside the cage, boiling water can be a control method, it is eco-friendly, but not too friendly to the ants !

13: Exporting Pupae:

13.1: Export and Import Regulations:

Before attempting to export you should familiarise yourself with both the export regulations from the country in which your farm is situated, and the import regulations into the country to which you are sending your pupae. You ignore these regulations at your peril, for though you may consider them unnecessarily bureaucratic, each country has a clear right to make its own laws, and if you do not abide by them you risk the chance of having your shipment confiscated. It is impossible in this manual to describe the laws for each country, but you will have to enquire about them to the countries you are interested in shipping to, as well as your own, in good time before your first parcel is sent. Your potential buyer should be very helpful in this respect.

13.2: Packing Pupae for Export:

Some producers ship their pupae in an extraordinarily untidy manner for example thrown in loose in old powdered milk tins or in flimsy cardboard boxes, with only screwed up newspaper to act as a cushion. Remember that your pupae are a valuable commodity and that your purchaser will not pay you for pupae that are damaged because of your careless packing. It pays to make a little effort to present the pupae in a strong box, that is neatly packed. The box can be made from either solid wood or plywood. If solid wood is used it should be a fairly light wood to avoid excessive weight, but it should not be so soft that it can be easily pierced by sharp items. I have found that the most satisfactory material for constructing boxes for export is plywood. A box is prepared using ⅜" and ¾" plywood. The sides and bottom are pinned and glued and the top is simply cut to fit on top. The whole inside is lined with 1" foam. A layer of cotton wool is placed in the bottom and the pupae are laid in rows, each packed in a sheet of tissue. Labels are added to each batch indicating species, date of pupation and number in batch. When one layer is filled, another layer of cotton wool is placed in position and another layer of pupae until the box is filled.

13.3: Logistics of Pupae Production:

The number of pupae that can be shipped per week is very much dependant on the time that a butterfly is in the pupa. A pupa cannot be shipped within twenty four hours of pupation, it is too soft, and however carefully it is packed will be misshapen on arrival and unacceptable.

Likewise, it cannot be shipped by a wholesaler within about forty eight hours of its expected date of hatch. If the time taken to move the pupa from farm to wholesaler by courier is four days, then if parcels are sent weekly, only the following number of days production can be sent each week according to the length of time in the pupa:

Pupal longevity:	Days production saleable per week:
10	3
11	4
12	5
13	6
14 +	7

This is only an example to illustrate the principle, it may be that a longer period will be required for shipping at the end or a shorter time at the beginning. On this example if pupae are only shipped once a week in one parcel then butterflies with a pupal life of less than twelve days become increasingly uneconomic.

14: Value of Butterfly Farming:

Of course there is no denying the fact that the main reason to set up a butterfly farm is to sell pupae to butterfly exhibitions mainly in the temperate areas of the World and thereby make a profit. However in this process much good is done. The exhibition of tropical butterflies to the general public and particularly to children in these countries; helps to reinforce the message that our natural World and particularly the rainforest must be preserved for us and the coming generations. The income generated in employment in the tropical countries is also very important, for when breadwinners are fully employed they stop or reduce their farming operations, this can mean a significant cessation of slash and burn in the area, that is so damaging to the rainforest. No one can pretend that this alone will answer all of the problems, but butterfly farming can be a pointer to other ways in which rainforest resources can be tapped without destroying the forest and its ecosystems. It also has an important educational effect on the people around the farm. To these people before butterfly farming becomes operational, they know much about certain aspects of the forest, for example animals and birds that are good to eat, useful timber trees, edible wild plants and fruit and medicinal herbs; but, contrary to popular belief they know little about wildlife that do not touch on the practicalities of their everyday life. When they see the economic potential of an apparently worthless object such as a

butterfly, they also become much more interested in the conservation aspects of the forest.