

# Chapter 1

## Introduction



This chapter introduces the diversity of insects and the reasons for their success. Furthermore the ecological importance of insects and their role in the life of humans are briefly discussed. Conservation aspects and the sustainable use of insects are summarised and finally biogeography and the distribution of insects in the South Pacific are outlined.

### 1.1 Insect Diversity

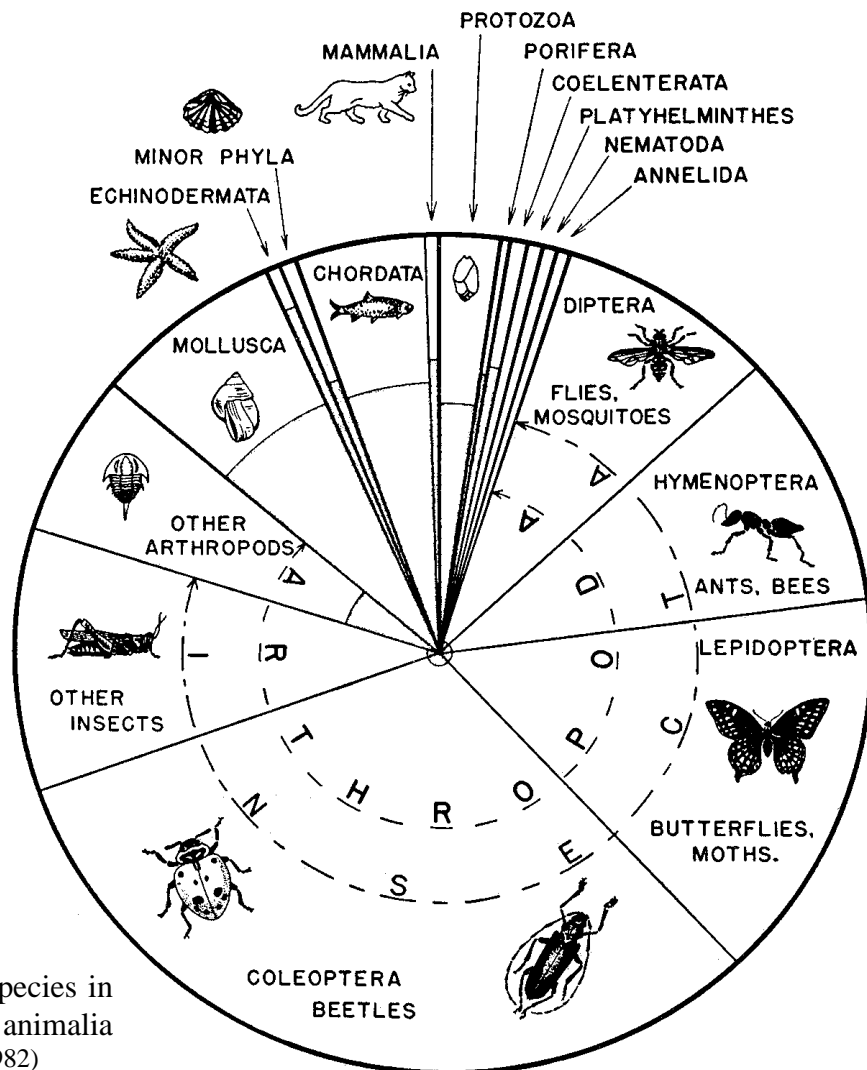
One good reason for studying insects is their tremendous diversity. Scientists assume that the total number of species is somewhere between 4.4 and 100 million. 76.3 % of the species are animals. Approximately ¾ of the animal species and more than half of the entire species including animals, plants, protista, fungi and bacteria are believed to be insects. Only two insect orders, the beetles and the butterflies and moths make up almost half of all animal species. In other words: every second animal species is either a moth, butterfly or beetle as shown in **fig. 1-1** and more than five out of ten species are insects. However, these figures are just estimates since only a fraction of the species has been described so far, as indicated in **box 1-1**.

The forests in PNG house an amazingly stunning **biological diversity** that can hardly be beaten by any other part of the world. Scientists presume that up to 6% of the world's total number of species can be found on the island of New Guinea with a high degree of **endemism**.

Taxon	identified	estimated total no.
mammals	4,170	4,300
birds	8,715	9,000
amphibians	3,125	3,500
insects	750,000	2.5 - 65 million
total no. of species	1.3 million	4.4 - 100 million

**Box 1-1:** Number of identified and estimated total number of species of selected taxa

Although at present, PNG can't compete with the world's fastest car or tallest building, it does have a number of impressive insect **superlatives** to offer from its immense species richness. The world's largest and second largest butterfly, the largest moth, the longest beetle, the largest katydid, one of the longest stick insects and other superlatives shown on **Plates 5 L, 8 I, 9 A, C, E** and in **box 1-2** can be found in PNG. The people of PNG are lucky and can be proud of the biodiversity PNG has to offer, since most of these outstanding creatures can be found on New Guinea only.



**Fig. 1-1:** Relative number of species in the orders of the kingdom animalia (reproduced from Ross, H.H. et al., 1982)

**PNG is the home of ...**

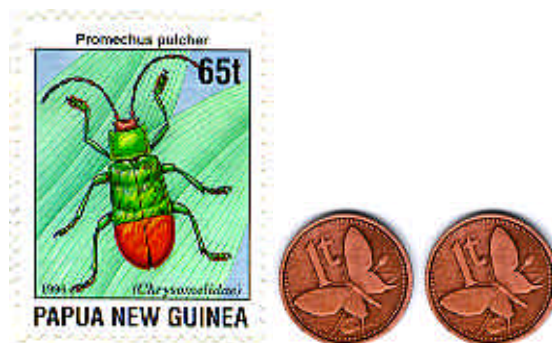
- the world's largest katydid *Siligofera grandis*
- the world's longest beetle *Batocera kibleri*
- the world's largest moth and one of the largest insects, the Hercules moth *Coscinocera hercules*
- the largest butterfly, Queen Alexandra Birdwing *Ornithoptera alexandrae*
- the world's second largest butterfly, the Goliath Birdwing *Ornithoptera goliath*
- one of the world's rarest butterflies, the Paradise Birdwing *Ornithoptera paradisea*
- *Hermachus morosus*, one of the world's longest stick insects
- *Graphium weiskei*, what some people consider as one of the world's most beautiful butterflies

**Box 1-2:** PNG's superlatives - the world's largest, longest, tallest...; see also **plates 5, 8, 9**

There are several reasons for the diversity of insects, outnumbering any other group of organisms. The fact that most insects are winged, allows them to conquer the air, which can't be used by terrestrial organisms. Thus competition is decreased increasing their rate of survival. Furthermore, due to their small size insects can complete their life cycles in short periods of time, which allows several generations per year or season. The tremendous reproductive potential of insects is another reason for their success, enabling a pair to produce hundreds or even thousands of offspring during their life. Finally insects are adapted to all heterotrophic levels, using any available source of food as herbivores, predators, parasites, omnivores and scavengers. The specialisation of insects on all heterotrophic levels is a major reason for their great success and ecological importance. Decomposing insects like dung beetles or termites are very important for nutrient recycling. They help to decompose organic material thus making available minerals for the growth of plants. As prey many insects provide food for predators, others are predators and parasites themselves. This contributes to regulate insect populations naturally. Insects are of essential importance for the pollination of plants, and highly specialised adaptations between flowers and particular insects have evolved. Furthermore phytophagous and seed-feeding insects maintain plant community composition and help to control weeds.

## 1.2 Insects and Humans

Commonly humans tend to have a rather negative conception about insects. Negative aspects of insects prevail especially in a tropical country like Papua New Guinea, where man is continuously attacked by parasites like mosquitoes, bed bugs, lice, fleas, sandflies and other nasty little creatures. We do not only have to sacrifice our blood, but take the risk of being given malaria by mosquitoes, suffering from scabies mites that live in the skin of humans or stubborn and long-lived sores caused by flies sitting on initially harmless scratches. Therefore the fear of insects, also called **entomophobia** is a quite understandable phenomenon.



**Fig. 1-2:** Insect motifs on stamps and coins, like *Ornithoptera paradisea* on one toea coins

On top of that, insects are not only harmful as parasites of man but they also adversely interfere with man's interest in raising livestock, keeping pets and cultivating various crops. From an economic point of view insects can become a severe headache for foresters, agriculturalists and horticulturists. Growing crops or raising livestock sometimes turns into an expensive exercise to control insects in order to avoid an even bigger economic loss caused by the particular pests.

The diversity of insects in the tropics results in a considerable diversity of insect pests as well. Everywhere in our gardens or plantations we can see these little creatures cutting, chewing, gnawing, sucking or mining various parts of the plants. For an agriculturalist or forester it means that it does not make much sense to plant crops without having a decent and sound

understanding of entomology. An agriculturalist or forester should be able to identify insects either from collected specimens or from the signs of damage, monitor the populations of potential insect pests, calculate the economic loss caused by insects and finally take preventive or curative measures in order to control insect pests.



**Fig. 1-3:** Simbai green beetle helmet (photo McKie, G. & McKie, R.)

But we should not forget that there is also a big number of insects beneficial to humans. Insect predators and parasites are most important agents for biological pest control. Chemical compounds like wax and honey are produced by honey bees like *Apis mellifera*, silk is made from the cocoons of the silk moth *Bombyx mori*, a red dye called ‘cochineal’ is derived from the scale insect *Dactylopius coccus* and the lac insect *Kerria lacca* is the source for a varnish called ‘shellac’. Moreover, research uncovered even further chemical compounds derived from insects with pharmaceutical and other useful properties.

Insects provide many opportunities for researchers and some species are invaluable for applied sciences. The vinegar fly *Drosophila melanogaster* for instance, is a commonly used model in genetic research. The aquatic larvae of certain insects are very susceptible to pollution, therefore their presence or absence can be used as a biological indicator for water quality. Usually lengthy floristic surveys are carried out in order to determine biological diversity, but moths are currently under scrutiny to determine whether they can be used as a more convenient measure of biodiversity.

Artists are inspired by insects as shown in **figs. 1-4** and **2-45** and insect motifs are widely used in daily life (**fig. 1-2**). Furthermore, all seven species of Birdwings are **National Animals** of PNG. Insects like jewel beetles and rose chafers were and are still traditionally used for body decoration, as shown in **fig. 1-3**.

Insects like termites, ants, locusts and beetle larvae are an important source of protein for many people and they are delicious. People of the Sepik appreciate sago beetle grubs; a recipe is given in **box 1-3**. In Africa large quantities of grasshoppers are consumed during outbreaks of plague locusts. About 500 species of insects are used in entomological cuisine mainly in Africa, Asia, Southern America and Australia. With increasing populations and the ongoing depletion of resources, the use of insects for human consumption will become much more important in future. Apart from being food for humans, insects are feed for domesticated animals.

Finally, insects cater for a sustainable long-term income for small-scale insect farmers, ranchers and collectors.

### Box 1-3: Recipe for Sago Grub Saté

<b>3 doz. sago grubs</b> ( <i>Rhyncophorus spp.</i> , Coleoptera: Curculionidae)	Steam the sago grubs for about ten minutes. Heads can be removed, if desired.
<b>Peanut Sauce:</b> <b>150 g ground freshly roasted peanuts</b> <b>or 150 g peanut butter</b> <b>4 to 6 chillies, finely chopped</b> <b>1 clove garlic, crushed</b> <b>1 stem lemon grass, chopped</b> <b>1 tablespoon lime juice</b> <b>2 table spoons soy sauce</b> <b>200 ml coconut milk, salt</b>	Meanwhile combine all the sauce ingredients and heat, but do not boil.
	Put the grubs on saté sticks (6 to a stick) and cover with half of the sauce. Grill over a charcoal fire or under an electric grill for about five minutes, then turn over, cover with the rest of the sauce and grill for another five minutes.
	Serve with rice. This is a very rich dish. <b>Bon appétit!</b>

### 1.3 Insect Trade and Conservation

Papua New Guinea is the home of one of the last remaining, relatively undisturbed tropical rain forests, covering about 70% of PNG's land surface. It is presumed that most of this forest will have disappeared within the next 50 years, if deforestation continues at the current pace. Shifting cultivation is responsible for approximately two thirds of the rate of destruction whereas one sixth of the loss is due to logging. Man's impact on the environment remains not without consequences for organisms living in the forest. Often **habitat destruction** causes the threat as in the case of the Queen Alexandra Birdwing *Ornithoptera alexandrae*. Large areas of forest in Oro Province were cleared for the establishment of oil palm plantations but not only the forest vanished. The food plant of this butterfly disappeared as well, thus driving it almost to **extinction**. Many species are already in a critical state making it necessary to protect certain animal species. In PNG only seven insect species are so far protected by the PNG Government following recommendations of the International Union for Conservation of Nature and Natural Resources (IUCN), even though many more vulnerable species are supposed to enjoy protection. The 1994 **Red List of Threatened Animals** lists *O. alexandrae*, *O. chimaera*, *O. meridionalis* and *O. paradisea*. The Convention on International Trade in Endangered Species (CITES) lists all Birdwings occurring in PNG as restricted species in Appendix B, except the Queen Alexandra Birdwing which is listed as a protected species in Appendix A. However, *Troides oblongomaculatus* and *O. priamus* are not protected by PNG legislation, but were protected by IUCN only for the convenience in identification by customs officers.

PNG's rich insect fauna has always attracted man's attention. Colourful iridescent insects have been used for body decoration during traditional celebrations. Collectors and tourists are impressed by the colours, size and beauty of butterflies and beetles and wish to purchase for instance a horrifying huge and ugly spider as a souvenir for display next to the plastic Eiffel tower in the lounge of their homes.

The government of PNG recognised this demand and its economic opportunities two decades ago and established the Insect Farming and Trading Agency (IFTA) in charge of marketing and the international trade in insects. IFTA is a non-profit governmental agency, belonging to Unitech Development and Consultancy (UDC) and is the only gazetted agency allowed to export insects. Apart from IFTA, there are several other, mostly non-governmental organisations like Wau Ecology Institute (WEI), that are involved in extension programmes. These aim at training villagers in the collection and preservation of insects. The extension programmes also try to identify suitable insect species for marketing and encourage villagers to propagate larval food-plants either in enclosed **butterfly farms**, in gardens or in the bush (**butterfly ranching**), as shown in **fig. 1-5**. By planting the respective foodplants, the females are invited to lay their eggs on the plants so that the pupae can be easily collected and sold by the villagers. This minimises catches from the forest and increases the efficiency of producing particular butterfly species and thus caters for their increasing demand.

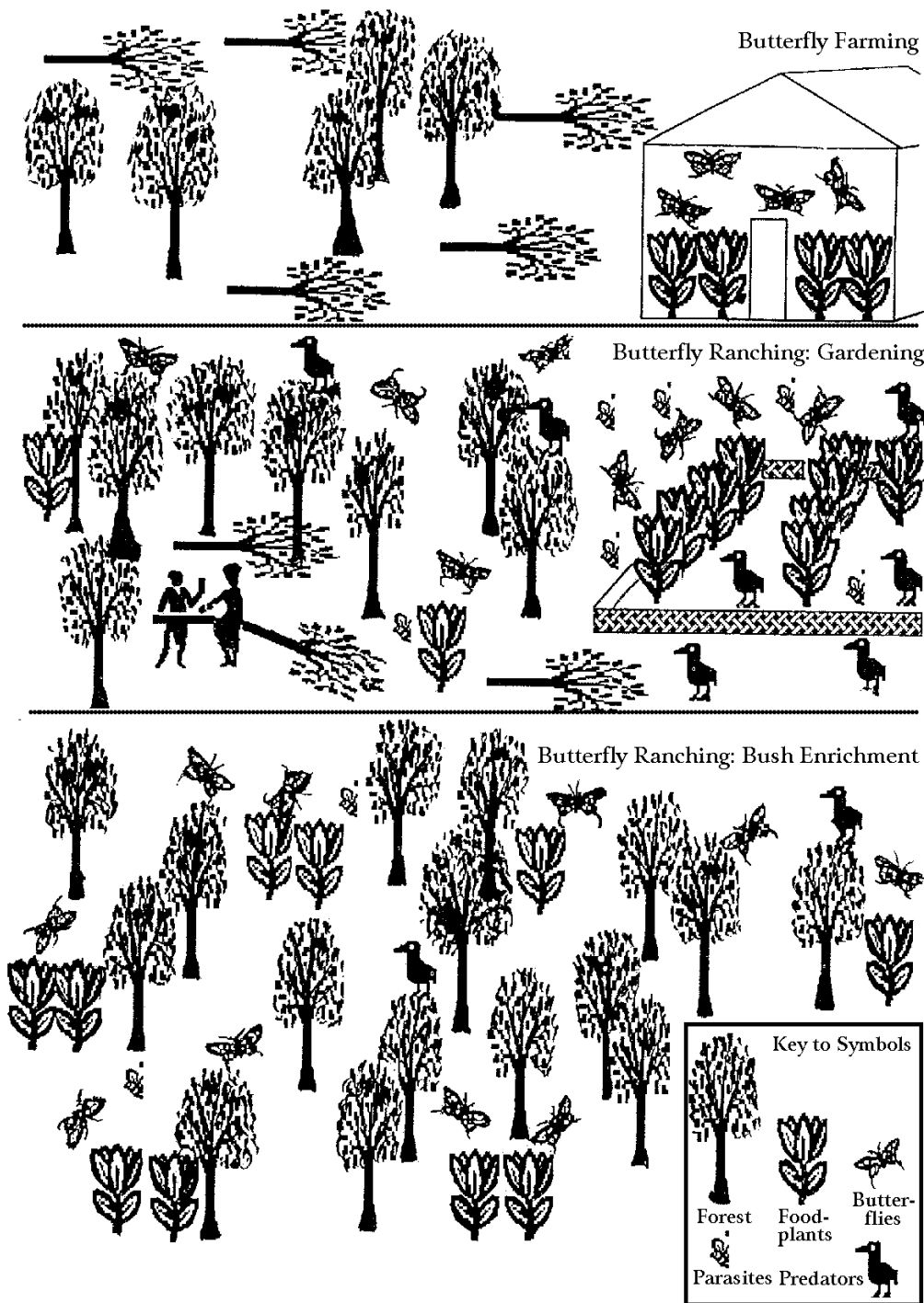
Unlike the utilisation of other forest products, the insect business positively reinforces the conservation of tropical rain forests. Many



**Fig. 1-4:** M.C. Escher's "Butterflies" © 1999 Cordon Art B.V. - Baarn - Holland. All rights reserved.

insects are closely associated with undisturbed forests, hence, most insects disappear once the forest is gone. Furthermore, the ecological impact is rather negligible as regular monitoring proves no decline of the wild populations due to over-collecting. As a result of successful farming and ranching programmes, most of the wanted Birdwing species are not banned from trade, except *O. alexandrae*. Thus, the insect business is referred to as an outstanding example of the truly **sustainable use of a resource**.

In terms of the economy, the use of the resource 'insect' is definitely not of great significance when compared with other forest products such as timber. However, the insect business requires almost no equipment and an initial investment of only about K 15.00 for the purchase of an insect net and perhaps some bush materials. This is a real advantage when starting a small-scale business that can secure a small but regular income on a long term basis. Currently approximately 1500 collectors from all over the country supply insects with an annual export value of about one million Kina. For most collectors from rural areas, collecting and selling insects is the only means of generating income, thus the revenue contributes markedly towards their living. Most of the insects don't fetch more than 10, 20 or 50 toea, however particular insect species from Aseki, Bougainville and New Britain islands are a real bonanza: some jewel beetles like the colourful *Metaxymorpha* and *Calodema* (plate 3 N and O), the rare Birdwing *O. meridionalis* and rare Birdwing hybrids are worth up to several hundred Kina when sold to IFTA.



Butterfly Farming

Butterfly Ranching: Gardening

Butterfly Ranching: Bush Enrichment

Key to Symbols

- Forest
- Food-plants
- Butterflies
- Parasites
- Predators

**Fig. 1-5:** Butterfly farming and ranching via garden plantings and bush enrichment (reproduced with permission from Orsak, L., 1993)



**Fig. 1-6:** CITES-stamp issued for the export of restricted species

About 75% of the insects are exported mainly to Germany, Japan and the USA, the remainder is for the domestic market. Insects bound for export have to be accompanied with the required **export permit**, issued by the Department of Environment and Conservation (**DEC**) and signed by the Conservator of Fauna. The permits for non-CITES specimens can be obtained from IFTA when buying insects in a display box. IFTA also assists in applying for CITES permits for the protected Birdwing species. These permits bear a CITES-stamp, as shown in **fig. 1-6**. Heavy penalties are imposed for the attempted illegal import or export of specimens protected under CITES.

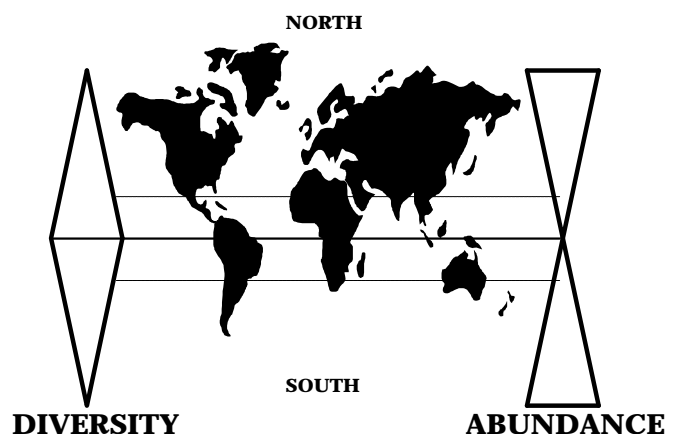
## 1.4 Biogeography of Insects

Insects conquered almost the whole biosphere, they dwell soil, in water and air, live on plants or inside other organisms. Some can even be found on glaciers high up in the mountains. The only places they can't be encountered are marine ecosystems.

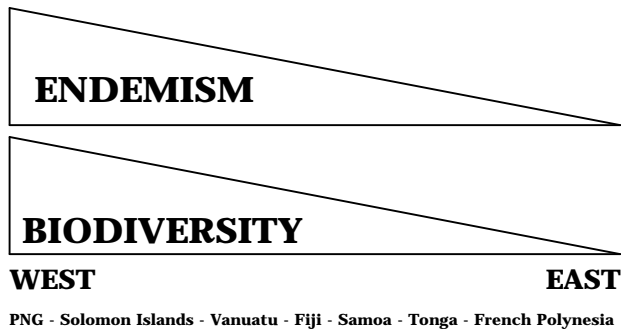
The study of **biogeography** elucidates the distribution of species throughout geographic areas. As shown in **fig. 1-7** the species richness of insects and in general of most other organism groups decreases from the equator or tropics towards the poles or temperate areas. The highest diversity of organisms is associated with the tropical rain forest, that occurs along the equator, especially in the Amazon basin (Brazil), the Congo basin (Zaire) and the Indonesian archipelago (including the island of New Guinea). Having a look at the number of individuals per species (**abundance**), a situation contrary to the diversity can be found: increasing abundance towards the poles (see **fig. 1-7**). This phenomenon can be shown impressively with insects attracted to a light during the night. For instance in Europe the

result would be a few species, but many individuals per species attracted to the light. However in PNG one could find very many species with one or two individuals per species only. Regarding the species richness along an altitudinal range, scientists found that the highest biodiversity is found between 500 and 1,000 m above sea level. Higher elevations show lower diversity but a higher degree of endemism. Some insects like weevils (**Curculionidae**) are particularly diverse in mountainous rain forests.

Looking at the situation in the South Pacific, we find that many Pacific islands are relatively young, or like New Guinea island as part of the Pacific plate have been separated from the large continents for a very long time. Due to the large distance between the eastern islands like Samoa and Tonga and the Asian and Australian continents, migration of insect species is drastically reduced. As a result of this isolation, a unique flora and fauna evolved on these islands. The size and the age of the islands have a great influence on the number of species that can be found on a particular island. For instance a tenfold increase in area results in a twofold increase in (ant) species. The larger and older the islands are, the higher is their biological diversity. High biodiversity is also the result of high **geological activity**, eg. volcanism, earthquakes and resulting land slides. These habitats are always subject to vast alterations, with the consequence that species living in those areas either have to adapt to the



**Fig. 1-7:** Longitudinal variation in biological diversity and abundance (graphic Schneider, M.F.)



**Fig. 1-8:** Biodiversity and endemism in the South Pacific (graphic Schneider, M.F.)

changing environmental conditions or become extinct. According to **Charles Darwin's** evolutionary theory, this promotes the evolution of new species. Lastly, the tropical rain forest located along the equator provides ideal conditions for a tremendous number of species, not met by any other ecosystem. Within the South Pacific a decrease of **biodiversity** and **endemism** of the insect fauna from West to East occurs, as shown in **fig. 1-8**.

The insect fauna of New Guinea Island (**please note that the term is used for the entire island, politically consisting of Papua New Guinea and Irian Jaya**) shares species with neighbouring countries. There are quite a number of species like the Hercules moth or the Priamus Birdwing in common with Northern Queensland. A few New Guinea species like the Priamus Birdwing can be also found in the Solomon Islands, as well as the Indonesian archipelago. The majority of species however are endemic to New Guinea or to particular parts of the country. An example is the Queen Alexandra Birdwing *Ornithoptera alexandrae* that is found only in Oro Province.

Other New Guinea insect species are **cosmopolitan** or **ubiquitous**, meaning that they can be found all over the world. Insects closely associated with man, such as cockroaches and human lice were accidentally introduced to the island of New Guinea or followed man during the early settlement. Other insects for instance pest species were introduced with crops, their respective host plant or were introduced as biocontrol agents. In this context, **quarantine** is of extreme importance for island nations like PNG or Australia.

### Further reading:

- Bernays, E.A. (1991): Insect-Plant Interactions; CRC Press; Boca Raton; USA
- Beehler, B.B. (ed.) (1993): Papua New Guinea Conservation Needs Assessment; Vol. 2; Biodiversity Support Program and Department of Environment and Conservation; Boroko; PNG
- Cherikoff, V. and Isaacs, J. (1989): The Bush Food Handbook; Ti Tree Press; Balmain; Australia
- Clark, P. and Landford, A. (1991): Farming Insects in PNG; Int. Zoo YB. (30), 127 - 131
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) (1996): Insects - Little Creatures in a Big World; CD-ROM; CSIRO Publishing; Collingwood, Australia
- de Foliart, G.R. (1989): The human Use of Insects as Food and as Animal Feed; Bull. of the Entomol. Soc. of America 35, 22-35
- Gressitt, J.L. (1968): Biogeography and Ecology of New Guinea; Vols. 1 & 2; Junk Publ.; The Hague; Netherlands
- Groombridge, B. (1993): IUCN Red List of Threatened Animals; IUCN; Cambridge; UK
- Groombridge, B. (1994): Global Biodiversity - Status of the Earth's living Resources; IUCN; Cambridge; UK
- Gullan, P.J. and Cranston, P.S. (1994): Insects - An Outline of Entomology; Chapman & Hall; London; UK
- Höft, R. (ed.): Proceedings of the Biological Society of New Guinea; Wau Ecology Institute; Wau; PNG
- Hölldobler, B. and Wilson E.O. (1994): Journey to the Ants - A Story of Scientific Exploration; Harvard University Press; Cambridge; USA
- Hoydt, E. (1996): The Earth Dwellers - Adventures in the Land of Ants; Touchstone; New York; USA
- Monteith, G. (1991): The Butterfly Man of Kuranda; Queensland Museum; Brisbane; Australia
- Orsak, L. (1991): The Wau Ecology Institute's "Insect Ranch" Programme; Wau Ecology Institute Leaflet; Wau; PNG
- Orsak, L. (1993): Killing Butterflies to Save Butterflies - A Tool for Tropical Forest Conservation in Papua New Guinea; News of the Lepidopterists' Society No. 3, pp 71-80; Lawrence; Kansas; USA
- Parsons, M.J. (1996): New Species of *Aristolochia* and *Pararistolochia* (Aristolochiaceae) from Australia and New Guinea; Botanical Journal of the Linnean Society 120: 199-238
- Parsons, M.J. (year indet.): Insect Farming and Trading Agency Farming Handbook; IFTA; Bulolo; PNG
- Robinson, W.H. (1996): Urban Entomology - Insect and Mite Pests in the Human Environment; Chapman & Hall; London; UK
- Sekhran, N. and Miller, S. (eds.) (1995): Papua New Guinea Country Study on Biological Diversity; Department of Environment and Conservation (DEC); Waigani; PNG
- Wilson, E.O. (ed.) (1993): Biodiversity; Nat. Acad. Press; Washington; USA