# IS *RAFFLESIA* A THERMOGENIC FLOWER?

A report presented

by

SANDRA PATIÑO

to
THE DAVIS EXPEDITION FUND

THE UNIVERSITY OF EDINBURGH
Edinburgh, Scotland
March 1999

## BACKGROUND

The aim of this study was to compare the temperature relationships of flowers that grow in the understorey of the rain forest with flowers that grow in sites exposed to high solar radiation such as beaches and disturbed areas.

In the understorey of the rain forest, the environmental conditions are fairly constant, with low wind velocity, small variation in the air temperature from day to night, high relative humidity, low light intensity, and low net incoming radiation.

In a recent study (Patino & Grace in preparation ) it was found that *Rhizanthes lowi* (Rafflesiaceae) a flower that grows in the understorey of the rain forest in Brunei, is a thermogenic flower that shows signs of thermoregulation (Figure 1). Thermogenic flowers are usually entomophilous i.e. flowers whose pollen is conveyed from the anther to the stigma by the agency of insects. The thermogenesis in flowers has been related to the emission of volatile compounds that attract insect pollinators. In cold environments, the thermogenesis in flowers seems to result in a direct reward to the pollinators

**Figure 1.**

*Rhizanthes lowi (Rafflesiaceae)*, a parasiticc plant on the roots of *Tetrastigma sp.*

*Rafflesia sps.* and *Rhizanthes sps.* are entomophily flowers. Their pollination depends on the attraction of carrion flies. These flowers have been characterized for the production of a strong odour which attract carrion flies as their natural

pollinators. The thermogenesis in *Rhizanthes sps.* flowers seems to be directly associated with the pollination process. The flower mimics a wound on the skin of a hairy mammal, a perfect place to deposit the eggs and find food (Banziger 1996). Thermogenesis may help to release the volatile compounds that produce the attractant smell. To date, the nature and chemical composition of the smell has not been investigated in these species.

As the genus *Rafflesia* and *Rhizanthes* belong to the same family (Rafflesiaceae) and are both parasitic on the roots of *Tetrastigma sps.* vines, do not have stems, leaves, or any photosynthetic organ, and are sympatric species in the South East Asia rain forest we wanted to investigate if *Rafflesia* flowers are thermogenic as *Rhizanthes* flowers are.

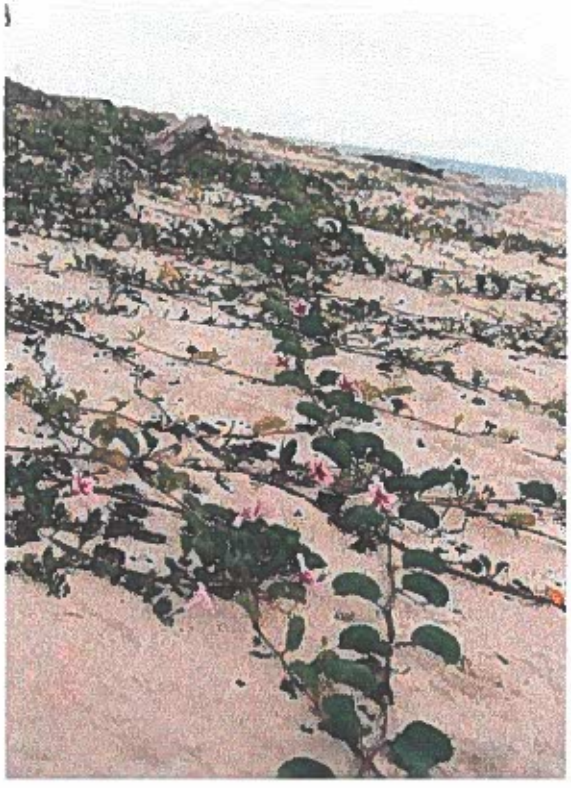


**Figure 2.**

*Ipomoea pes-caprae* growing in Berakas beach, Brunei.

On the other hand, flowers that grow exposed to high solar radiation may have mechanisms to prevent overheating and present different strategies to attract their pollinators. To test this hypothesis, flowers from the *Convolvulaceae* family were chosen (*Ipomoea pes-caprae*, *Merremia borneensis* and *Ipomoea aquatica*). These particular species were chosen because they were some of the most predominant species in Brunei. These species are both entomophilous and have very bright and

conspicuous flowers. *I. pes-caprae* generally grows on beaches and sandy areas (Figure 2). *M. borneensis* is a good climber and grows in disturbed areas, along many roads in the countryside and on trees at the edge of the forest (Figure 3). *I. aquatica* grows in swamps, dikes and flooded areas which are exposed to high solar radiation (Figure 4).

**Figure 3.**

*Merremia borneensis* growing at the edge of the forest in Brunei.

**Figure 4.**

*Ipomoea aquatica* growing in a swamp in Brunei.

This 9-month expedition to Borneo was a very rich experience in terms of my research work and my own personal experience.

I travelled several times from Brunei to Sarawak and Sabah (Figure 5) and I was able to interact with the local people and get a glimpse of the culture. I learned enough of the language (Malay) to be able to communicate with the local people in Brunei and Malaysia. I also learned a little of the Iban dialect and gained much more my from walks with the park staff in the forest looking for *Rafflesia* buds and flowers and the social events at the long house in Batan Duri (Temburong, Brunei).

Overall, it a was a very successful trip I studied 5 flowers of *Rafflesia tuan-mudae* in natural conditions and was able to find many sites on different beaches and

disturbed areas in Brunei and Sarawak to perform my experiments and measurements on *Ipomoea pes-caprae* and *Merremia borneensis*.

During my first trip to Taman Negara Gunung Gading, Lundu, Sarawak from the 11th to the 31st of July 1998 I studied one male flower in bloom and three semi-mature buds of *Rafflesia tuan-mudae*. I carried out experiments on the temperature of the flower and simultaneously collected the volatile compounds from the headspace of the flower (a more detailed account of the experiments and measurements is presented in Appendix I).

In my second trip to Gunung Gading from the 18th September to the 13th October, I studied three female flowers.

In November, I travelled to Kinabalu National Park to meet Dr. Jamili Nais, who studies *Rafflesia sps*. in Sabah. On this trip we could not find any Rafflesia in bloom.

On my third trip to Gunung Gading from the 13th to 17th January 1999 I studied one male flower.

During this trip the Borneo Post, a Newspaper from Sarawak (a copy of the article is presented in the Appendix II), interviewed me.

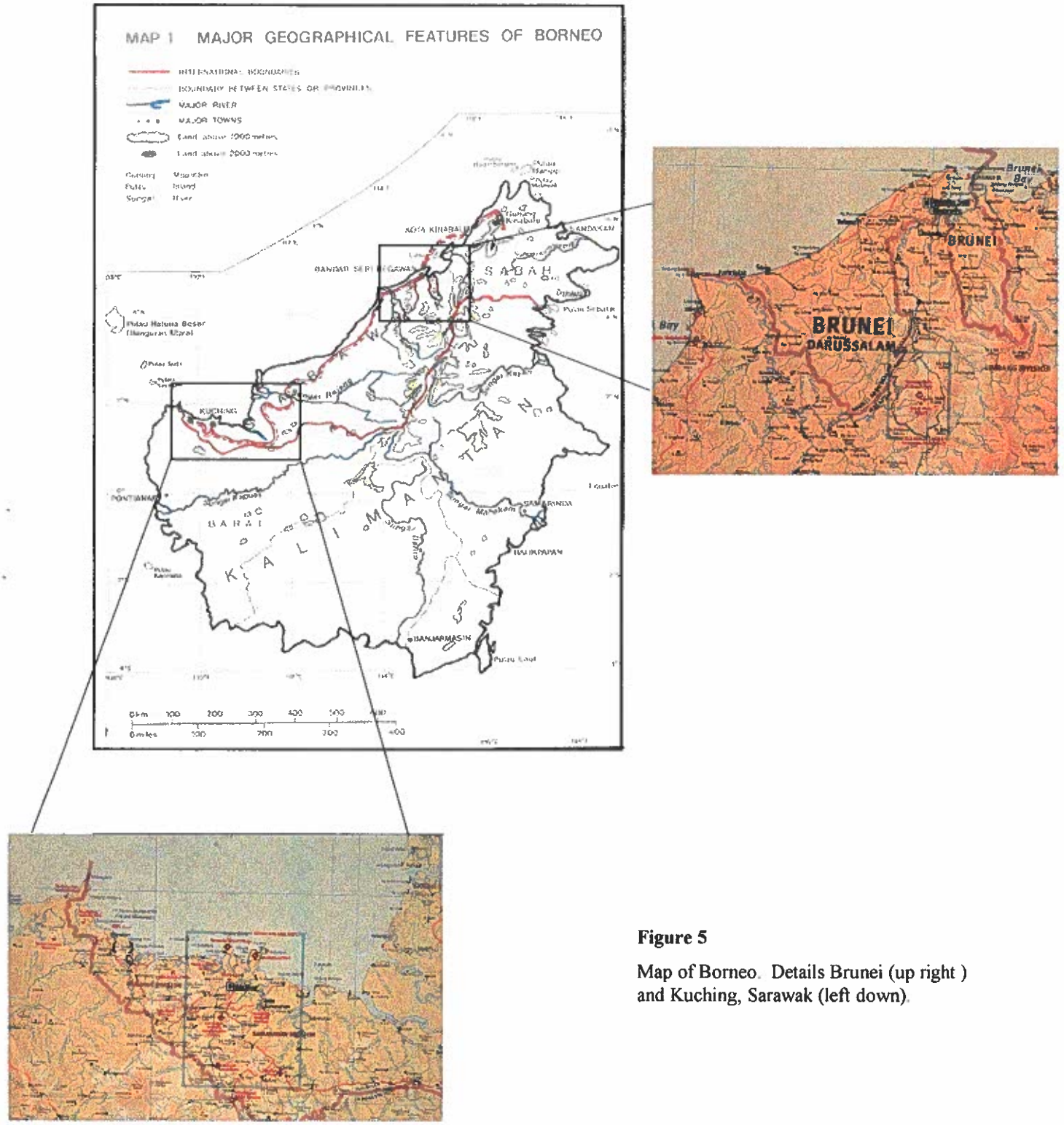



**Figure 5**

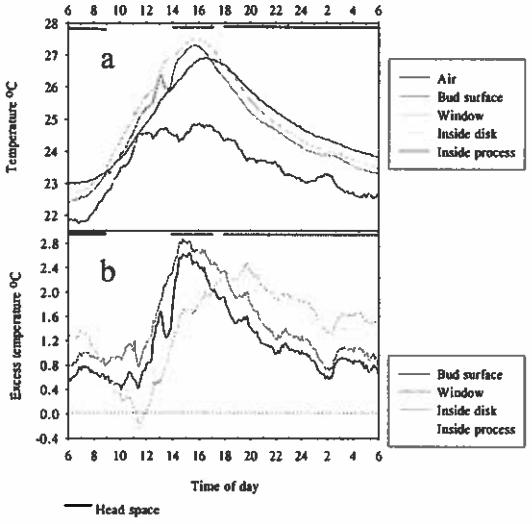
Map of Borneo. Details Brunei (up right ) and Kuching, Sarawak (left down).

## RESULTS

The results presented in this report are only a superficial illustration of my research, as analysis is still underway.

### *Rafflesia tuan mudae*

1- The temperature of different parts of the flower were usually higher than the temperature of the air, predominantly during afternoon hours. Figure 6a shows a typical diel course of temperature for one of the flowers in July 1998. There was



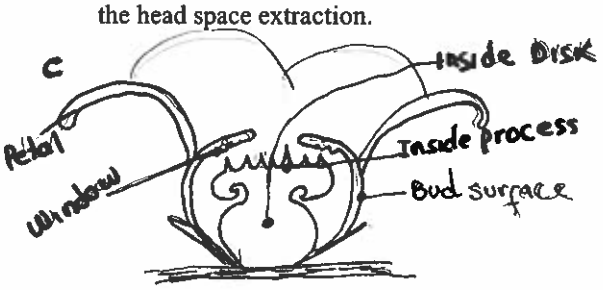




**Figure 6.**

Diel temperature course for *R. tuan mudae* on the 24th of July 1998 (**a**).

Diel patterns of excess temperature for different parts of the flower (**b**).

The horizontal line indicates the time of the head space extraction.

not a significant difference between the temperature of external and internal parts (Figure 6a). The maximum excess temperature (the difference of temperature between the air and any part of the flower) was 2.8°C for the window (Figure 6b, 6c). There seems to be a difference in the excess temperature pattern for internal and external parts since the pattern of the external parts are more related with the net radiation. The temperature of internal parts seems to be more independent of the net radiation.

2- From the *R. tuan mudae* headspace there have been five volatile compounds identify so far; Dimethyl disulfide, 1,2-diethylbenzene, 1,3-diethylbenzene, 1,4-diethylbenzene, 2-ethyl-1-hexanol. Further analysis of the samples is necessary to complete the identification and classification of the volatiles that compound the odour. Figure 6 shows the periods of head space collection.

**Figure 8.**

Flowers of *Merremia borneensis* showing similar orientation and inclination angles.

### *Exposed Flowers*

1- Flowers show solar tracking (Figure 8). Measurements of orientation and inclination of *I. pes-caprae* and *M. borneensis* during different time of the year

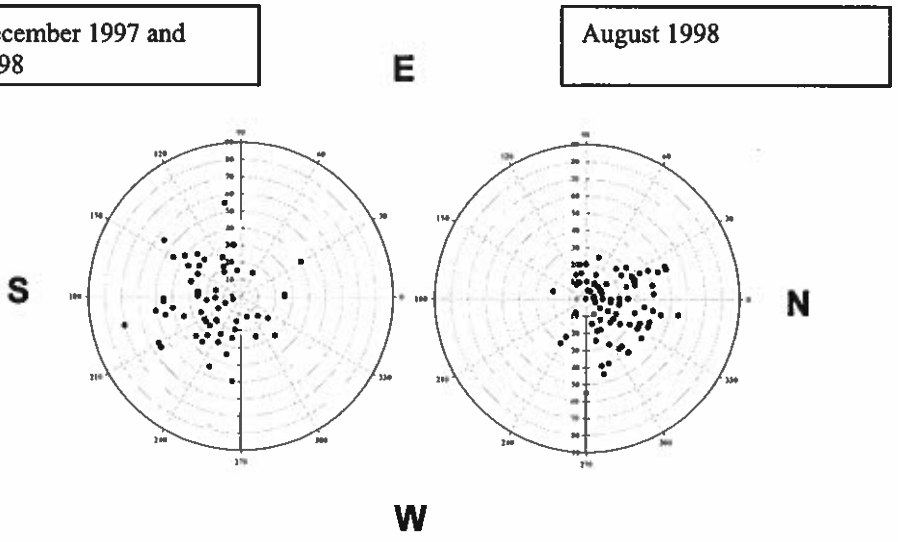



**Figure 9.**

Polar plot of the orientation and inclination angles of *Ipomoea pes-caprae*. At the end of the year (Winter in the northern hemisphere) the flowers seems to face south (left plot). In August (Summer in the Northern hemisphere) the flowers seem to face towards north (right

show that flowers change position depending on the seasonal solar position, (Figure 9).

2- Petals play the role of umbrellas to shade the gynoecium during morning hours.

3- After petal collapse, the sepals become the organ controlling the temperature of the gynoecium.

## CONCLUSIONS

It is still early to give conclusions of my results since I do not have all the data analysis ready.

I could comment about some points of my overall research.

The temperature of some parts of *R. tuan-mudae* flowers i.e. column, disk, window, were always higher than the air temperature. That could indicate some degree of thermogenesis.

During my trip to Sabah in search of *Rafflesia*, I learned from Dr. Jamili Nais that the population had dramatically diminisheed during the last year. Most of the buds died and there were not many blooms presumably because of El Niño drought in 1997. This was the case in Brunei for *Rhizanthes lowi*. There were non flowers in bloom during the whole of 1998 and all the buds died, the survival of *Rhizanthes lowi* in Brunei is in doubt.

There is not much known about the biology of these species and if El Niño was the real cause of the diminishing population. I hope this research will give some insight into the eco-physiology.

I hope to be able to publish the work about these two species and encourage the conservation and protection of the habitat.

Appendix I

## METHODS.

*Rafflesia flowers*

The internal and surface temperature was continuously monitored in different parts of the flowers: centre of the disk ($T_c$), disk ($T_d$), process ($T_p$), petal surface ($T_{ps}$), diaphragm surface ($T_{ds}$) air inside diaphragm ($T_{da}$), anther (male) ($T_{at}$), stigma (female) ($T_{st}$), and bud surface ($T_{bs}$).

Microclimate variables (Air temperature, ($T_a$), relative humidity (RH), wind velocity, net radiation, $R_n$, photosynthetically active radiation (PAR) were measured near the flowers. All the measurements were carry out for several days starting on the day of blooming until the flower decayed (5 to 7 days).

On the same flowers the head space technique was used to extract the volatile compounds emitted by the flowers during the blooming period (Figure 9). The headspace was sampled for periods of three hours during the day and for 10-12 hrs

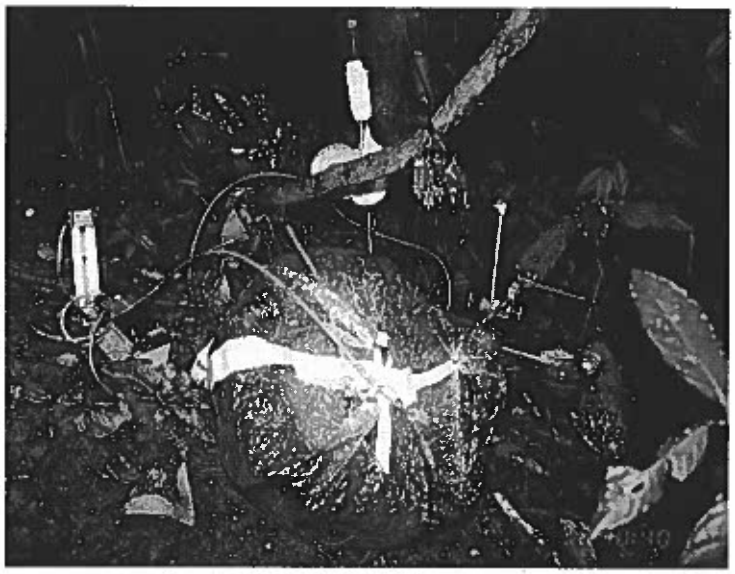


**Figure 9.**
Extraction of the volatiles emitted by *Rafflesia tuan mudae* using the head space method.

during the night every two nights. The samples were analyzed on a Hewlett Packard (HP) 5890 gas chromatograph (CG-MS).

*Exposed flowers.* Flowers of *Merremia borneensis* were studied in natural conditions in an open sandy area located at the University of Brunei Darussalam campus. Flowers of *Ipomoea pes-caprae* were studied on four different beaches in Brunei and Sarawak.

*Temperature and microclimate.* Several aspects of microclimate affecting flower temperature were studied for *I. pes-caprae* in August and September 1998 and *M. borneensis* during January 1999. Temperature of the gynoecium, corolla, and sepals were recorded on four flowers simultaneously. In two of the flowers, the sepals and the corolla were covered with silicone grease to prevent evaporation, whilst the other two were controls. After the corolla folded naturally between 12:00 and 13:00, it was excised and the thermocouples were re-located on the surface of the sepals. The microclimate variables, air temperature, relative humidity, wind velocity, net radiation, PAR, were measured in the same way as described above for *Rafflesia tuan mudae*.

Inclination and orientation of the flowers were recorded for each experiment. Additional measurements were performed for flowers growing in different locations different times of year in Brunei and Sarawak.

Sequences of flower photographs were taking to determine the floral area that is presented for interception of solar radiation

Apendix II

from: Borneo Post (Sarawak) Fri. 22/1/99

# Colombian student researching on rafflesia at Gunung Gading

KUCHING: Sandra Patino, a student from the University of Edinburgh on a scholarship from the Colombian Government, has been doing research on the Rafflesia at the Gunung Gading National Park since last year for her doctoral thesis in biology.

She has been on three trips so far - in July and October-November (for one month) last year and one week on this trip. Attached to the University of Brunei for seven months, she decided to come to Gunung Gading National Park to do her research on this famous parasitic flower-plant after hearing about it.

"In Brunei, there is another species of Rafflesia," she says. "It is from the same family but is of a different genus or specie."

Sandra told the Borneo Post she still has to analyse the data she has collected "but I'm studying the volatile Rafflesia famous for the pungent smell it produces. I try to identify the volatile chemicals that produce the smell.

"I've already identify some. I also study the temperature relationships to see if the environment influences the emission of the volatile chemicals. That's the main area of my research.

"I'll send a copy of my Ph D thesis to the Sarawak Forestry Department - it's all about the control of temperatures in tropical plants.

"My job as a biologist is wonderful as I get to be away from the town. During my research, I spend most of my time in the forests. After that, I have to spend one year writing my thesis in Edinburgh."

What is the use of research on a flower like Raflessia? "It is always good to know," stressed Sandra.

"Rafflesia is an endangered species. It is good to know what requirements are needed to protect it. The more knowledge you have, the more able you are to enable it to survive. So I think knowledge is very important."

After the thesis, she will be going back to Columbia to teach and do research there.

"Why did she have to come to Borneo since South America has tropical rainforests too? "Because you have completely different species of plants, different compositions of the forests, different cultures," she pointed out.

"That's why I like it - it's very different here."

Away from her research, Sandra likes to do little trips by mountain bike, swimming and reading novels and science (astronomy is her favourite subject).

At the very beautiful and scenic Pandan beach some kilometres from the Gunung Gading National Park, she also managed to study the 'Ipomoea', otherwise more commonly known as the morning glory.

She left for Brunei by car on Sunday with two French biology students who are also on attachment to the University of Brunei.

Appendix III

Expenditures:

| | |
|---|---|
| Travel: | £ 805.29 |
| Transport (Car, petrol, ferry) | £ 512.6 |
| Accommodation (Research station and parks fees, hotels) | £ 585.36 |
| Shipping equipment and post | £ 575.6 |
| Consumables | £ 578.87 |
| **Total** | **£ 3058.84** |