Moths as potential indicators of habitat quality in tropical peat-swamp forest

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by

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1. Introduction

1.1 The moth project

Figure 1: An adolescent Orangutan in Central Kalimantan

The Sebangau peat-swamp forest is a critical area for the conservation of biodiversity in Borneo, as it contains the world's largest orangutan (figure 1) and agile gibbon populations. Despite this, it is threatened by a number of anthropogenic disturbances. Eventually the effects of these disturbances and conservation initiatives on forest quality and species abundance are unclear. The idea was raised to select and monitor certain indicator species, which can be used as indicators of habitat quality. These species should respond both rapidly and predictably to changes in habitat quality. Moths are a potential group that may satisfy these conditions, and this project will therefore investigate their potential as indicator species in tropical peat-swamp forest. In Sebangau only one study on moths has been done by H. Sutrisno who focused on moths diversity. (15) There has not been any study on using moths as indicators in peat swamp forests. Therefore this research will be a pilot study to investigate which method is the most effective in Sebangau.

Hypothesis

1. Differences in the species diversity and density of moths exist between areas of various / different disturbance levels/habitat quality (e.g., riverine, sedge and mixed-swamp habitat).
2. Differences in the species diversity and density of moths exist between forest gaps and closed-canopy areas.
3. These differences are related to variations in morphology, e.g., thorax volume as an indicator of flight investment

Sub-questions

1. Which methods are the most effective in practice and have the best results?

1.1.1. Moths as an Indicator

In 1919 Hall and Grinnell were among the first to use the indicator concept by comparing plant and animal species to habitats. Ever since the indicator concept has attracted

biologists, conservationists and governments to measure the quality of the habitat. Not only is this concept a cost and time efficient way to measure the quality of habitats, it also provides a method to measure anthropogenic disturbances. (4) These indicator species should respond both rapidly and predictably to changes in habitat quality. Moths are a potential group that may satisfy these conditions, and this project will therefore investigate their potential as indicator species in tropical peat-swamp forest.

Lepidoptera is the most diverse group among insects after beetles and Hymenoptera. Their order consists of 174.000 species, of which 90% is moth. Adult moths play an important role in an ecosystem as pollinators. Their larvae are mainly defoliators or flower feeders. In lowland forests there is a lower species diversity than in montane forests. The dominant tree species Dipterocarea have a high proportion of green leafs. The floral diversity of Sebangau is low but there is high proportion of green leaves. Due to this the diversity of moths is very low, and there are also no specific moths that are most common on peat swamp since they are mostly polyphagus, which means they feed on many kinds of foods. A lot of species found in Sutrisno's research were also found in the highlands. (15)

There are three main methods of collecting moths; netting, luring with bait and light trapping. All three methods were tested in Bawan and Sebangau. Luring with bait in butterfly traps (chapter two) and light trapping (chapter three) seemed the most effective. Therefore these two method will be described in this report.

1.2 Borneo

Borneo is known for its singular wildlife and spacious pristine tropical rainforests. The landscape offers a variety of habitats; mangroves, peat swamps, freshwater swamp forests, lowland Dipterocarp forests, ironwood forests, heath forests and montane forests. The island is built up in a complex ecosystem that has grown over thousands of years. Massive rivers squirm through these ecosystems as lifelines that are used for transport, communications, and freshwater sources for communities. The island is inhabited by endangered species such as orangutans, the clouded leopard, elephants and the Sabah rhinos. (14) Meanwhile the island keeps on revealing new species as they are constantly discovered. During the last 15 years more than three species are discovered every month. This means that between 1995 and 2010 more than 600 species have been discovered. (19)

1.2.1. Threats of the forest

There are three big threats to the forest of Borneo. The first thread is deforestation, forest fires, water catchments and habitat fragmentation by the worldwide growing demand of palm oil. Figure 2 shows an extensive palm oil plantation in Borneo. Palm oil is used in almost 10% of all grocery products such as chocolate, lipstick, bread and washing powder. Indonesia and Malaysia are the number one producers of palm oil producing 86% of the

world production. However research has proven that not entire Borneo is suitable for the production of palm oil. The heart of Borneo has slopes, unsuitable soil and impossible access to establish more palm oil plantages. This makes the inland forests safe from destruction. On the other hand lowland forests are threatened by deforestation. These forests are the most important habitats for most endangered animals including the elephant and the Orangutan. It is estimated that over the next 20 years each year 8000 square kilometers lowland forest will be cut. (18) The decrease of lowland forest causes both habitat loss and habitat fragmentation.(6)

Figure 2: Palm oil plantation in Central Kalimantan

The second thread is erosion by clear-cut forests. Eco systems are a natural well-managed buffer in natural forests. They provide local populations with drinking water. When forests are clear-cut and heavy rainfall occurs, the erosion in the heavy rainfall can cause sincere damage economically as well as socially. (19)

The third thread is an environmental problem that comes with the production of palm oil: the massive emissions of carbon dioxide(CO2). 11% of the island is peat swamp forest. This is an unique ecosystem built on 15 to 20 meters of organic material. The organic materials originate from plant remains which has built up for century's. This soil is a reservoir for carbon dioxide. To establish palm oil plantation, forests need to be cut or are set on fire, after which the carbon dioxide is released into the air. Forest fires in peat swamp are led through the ground. These fires can be natural or set by humans. Each year lots of forest fires are set and when they do, they are uncontrollable. These forest fires put Indonesia on the number 3 of greenhouse gas producers of the world. (18)

1.3 Locations

1.3.1 Sebangau

Until 1995 the Setia Alam Field station was a former timber logging company. Now the area is the research station of Orangutan Tropical Peatland (Outrop) management, managed by the Centre for the International Cooperation in Management of Tropical Peatlands (CIMPTROP) of the University of Palangka Raya. The Field station is situated on the other site of the river from the village Kereng ((2°45'45, 8"S 111°56'42, 4"). The Setia Alam Field Station is situated 20 kilometers Southwest of Palangka Raya in the upper reaches of the Sabangau River. The Sabangau catchment covers an area of approximately 9200 km^2 between the Katingan River to the west and the Kahayan River to the east (see figure 3).

Setia Alam Field Station is sited just inside the edge of the forest on the site of a former logging concession. Here there is an abrupt edge between the forest and the sedge swamp habitat that borders the river. The area that exists now of sedge swamp, once was covered by riverine forest, which has been cut down. The topography of the area is unique as it is situated only marginally above sea level. From the river edge to the upper reaches of the peat dome, the elevation increases by only 20 meter. Disturbance has not been uniform throughout the area and natural differences in forest character also occur, resulting in areas of different habitat quality. Also numerous canopy gaps occur throughout the area, as a result of previous logging disturbance, tree falls and creation of clearings for fruit-bat hunting.

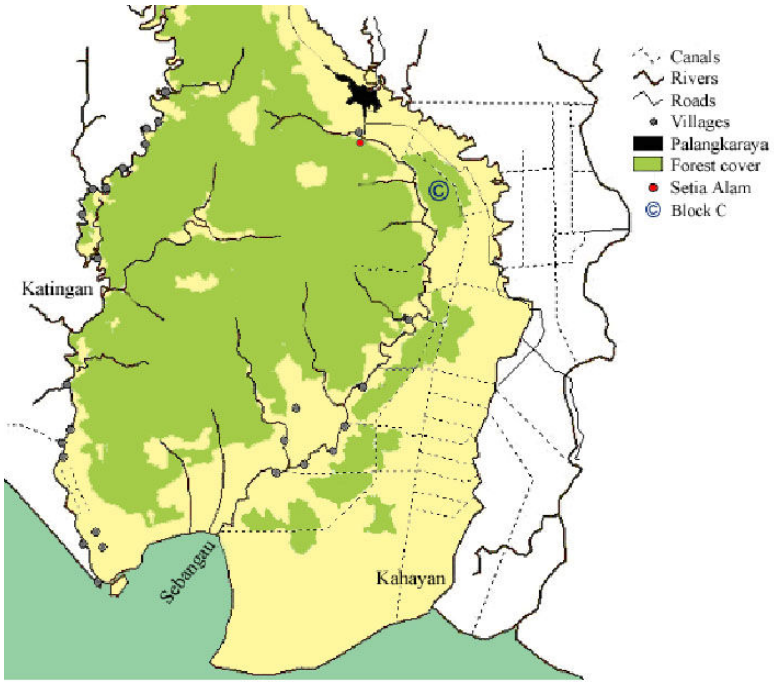

Figure 3: A map of Sebangau National Park

The forest in the eastern part of the catchment, between the Sebangau and Kahayan, is much more heavily fragmented. Between 1996 and 1998 the Indonesian authorities set about clearing this area of forest in order to convert the land into rice fields, an initiative that became known as the 'mega rice project'. First a network of massive canals was constructed in order to drain the peat then the commercially valuable timber species were removed. However, during the 1997-98 El Niño event, the area caught fire and the project was abandoned. In total one million hectares were cleared of forest and the area continues to burn annually.(13)

1.3.2 Bawan forest

The Bawan forest is a remote rainforest region situated north from Outrop's base in southern Borneo. The Bawan research station has been established in June 2010 after CIMTROP was approached by the elders of the local village of Bawan to help them protect

this forest. The forest is a key watershed and of cultural importance for the local community. CIMTROP asked Outrop to conduct biodiversity surveys to describe the importance of this area for biodiversity conservation, thus adding weight and international recognition to the local driven claims for conservation of this area.

2. Method 1 Butterfly traps

2.1 Introduction

The idea of using Blendon butterfly traps (figure 4) came from the butterfly project carried out by S. Nolan in Bawan in July 2010. During this research not only butterfly's were attracted to the traps but moths as well. Because in every trap a relevant set of species was found it was decided to continue using this method.

Figure 4: A Blendon butterfly trap

2.2 Method & Material

2.2.1 Butterfly traps

The Blendon butterfly trap is shown on figure 5. During the day/night moths are attracted to the bait in the traps. The trap exists of a fine meshed gauze. The bottom of the trap exists of a plateau with a small entry around it for the moths. They will fly into the entry on the plateau, on the bottom of the trap were the bait is. Once they are done feeding the moths tend to fly upwards rather than horizontal, after which they are trapped. The moths can be carefully caught with the index finger and thumb squeezing its thorax gently. The moths are caught to be photographed, marked and measured. It needs practice to do this right, and also to find the right pressure to gently press the thorax. The wing length as well as the body

Figure 5: Holding a moth by the thorax

length were measured using calipers. The wings are marked with a marker pen, by numbers to prevent duplication. Hereafter the moths are photographed on both sides and released again. The photographs are later used for identification. All traps are situated at least 50 meters apart from each other. The traps are placed 5 to 10 meters above ground level. The studied area is divided in several different plots, which all have its own features. In every plot 4 to 8 traps are situated, which resulted in a route through each plot. In Bawan three different plots were subject to research; Kerangas forest, burned area and mixed peat swamp. In Sebangau 6 different plots were subject to the research; burned area, bat gaps , Setia aliam field station, railway, forest edge and canals.

2.2.2 Bait

The catches with bait traps are much smaller and less diverse than those with light traps. The moths collected with bait include a select minority of groups that is rarely seen. (9) Baits for moths include both savories as sweets. Noctuidae, Geomitridae, Cerura vinula en Pyraliden feed themselves with moist secreted by the eyes of big land mammals. This makes them parasites. Some of them absorb the fluid with their tongue where others have a tongue that cuts hair vessels which leads to bleedings where they feed themselves on. Butterflies as well as moths seem to be going out to find food before it begins to storm. (11) This could be due to the pressure difference climate wise. For the butterfly traps fermented banana bait was used, which was mixed with sugar and fruit wine (Indonesian Malagga). To investigate if the amount of moths and the diversity of species was different by savory bait, decayed chicken was used as bait.

2.2.3 Site description Bawan

Kerangas forest or *heath forest* is tropical moist forest with sandy soils. The sandy soils are often very poor of nutrients. The most common tree species is the Diptorocarp tree. The Dipterocarp tree species and other trees provide a high canopy. Throughout the entire forest water streams are found that are usually not deeper than one meter. This route starts 100 meter east from camp.

Burned area starts 200 meters south east from camp. The burned area was previously Kerangas forest. Now the area is an open space with scarce new vegetation. The ground is covered with charcoal trees and branches, some are still standing upwards.

The mixed peat swamp has a peat depth of 55 centimeters. The terrain is uneven due to many roots and waterholes. The canopy height in this area is approximately 20 meters with dense vegetation. This route starts 600 meters east south from camp.

2.2.4 Site description Sebangau

The canals in Sebangau are man-made water channels to distribute the wood from logging trees. The canals are approximately 100 centimeters wide and 90 centimeters deep. All canals have a constant slow current. Both the current, and the width and depth of these, vary a lot from day to day, due to rainfall. The canals can be compared to drainage systems

that are often used for water systems in agriculture land.
Bat gaps are open areas in the forest, with no vegetation nor trees. Bat gaps were made by the Chinese, to catch bats. These bats were used for medicinal causes. The populations of bats in Sebangau have drastically declined due to this hunt. The gaps vary in sizes but are approximately 25 by 10 meters. The vegetation and trees that have been cut for these gaps, cover the ground and are now drying out by the tropical sun.
The Setia aliam field station is located on the forest edge next to the river. The station exists of eight wooden longhouses connected by wooden boardwalks which are all covered with a roof. The ground underneath the longhouses is constantly flooded and still contains some remains of the trees that had to be logged to build the houses. Vegetation consists of ferns and rattan but is very scarce. Next to the camp a badminton court is situated. The sand on this court exists of dry white sand and is often a feeding ground for butterflies who feed on the minerals in the sand. The batgaps as well as the field station might be a new terrain for different communities to settle. When the traps were tested to be used for the study on butterflies, species were found that were not found in any other area. It can be concluded that the field station somehow provides nutrients for these species.
The Railway is a remain from the logging days. Small trollies were used to tranport the wood from the forest. The railway is approximately four to five meters wide and locally covered with trees and branches. The railway consists of two iron rails held up by wooden piles in the ground. The railway goes 2,5 kilometers south from camp into the forest. The two iron rails are connected by a boardwalk which is used to carry out studies in the field.
The forest edge was sampled for moth diversity. The samples were taken north-west of the camp. The part sampled is the edge of the forest next to the river. . The vegetation is not as dense as in the forest and almost no trees are present.
Traps were situated approximately 5 tot 10 meters above water levelTo compare samples from the disturbed area **standard Forest** samples have been taken.
Burned area is approximately 100 meters wide and 75 meters in length. It is located on the forest edge next to the river. The remains of the trees, plants and branches are still on the ground, half underwater, half dried by the sun. There is very scarce new vegetation growing. The area was burned down in 2007. Fire fighting teams prevented an uncontrolled forest fire in the Sebangau area (and also the burning down of the Setia Aliam Field station).

2.3 Results

2.3.1 Results Bawan

In table 2.1 the results of the pilot study in Bawan are shown. Fermented banana was used as bait. In Bawan only the moths who could be caught by the thorax are part of the data collection. The smaller ones were released without taking photos . The species found in the burned area are comparable to the collected data from Kerangas forest. The burned area was sampled for 11 days and Kerangas forest was sampled for 9 days. The amount of moth individuals in mixed peat swamp is significantly lower than the amount of individuals in

burned area and Kerangas forest. It can be assumed that mixed peat swamp has significantly lower floral diversity.(7) In the table the recaptured moths are included as well. Recaptured moths are the individuals that are trapped for the second time. The moths that are not marked escaped before we were able to mark them. A statistical analysis of the data will be performed at a later stage.

Table 2.1: The results from the route in Sebangau with banana bait

	Burned area	Mixed peat swamp	Kerangas forest
Traps	**9**	**9**	**9**
Total individuals	113	56	99
Escapes	12	4	22
Recaptured	10	8	13
Inactive traps	0	0	1
Not marked	11	2	3
Days	11	11	9
Date from	13-8-2010	13-8-2010	25-8-2010
Date to	23-8-2010	23-8-2010	2-9-2010

2.3.2 Results Sebangau

In table 2.2 the results of the collected data in Sebangau are shown. In these routes the sweet banana bait is used. In Sebangau not only the moths which could be hand caught were photographed but the smaller moths as well. Most individuals were found in the burned area, possibly due to the fact that some female moths prefer to lay eggs in a burned area compared to an unburned area. Despite the preference for burned area the significantly high amount of moths could also be species specific.(16) The data collected in the Standard forest are not representative compared to the data from other areas. This is because the bait was constantly taken by other animals than moths. It can be assumed that bigger animals such as gibbons or squirrels have taken the bait. The absence of bait as well as the motion of the traps, which are caused while the bait is taken, caused almost empty traps.
A statistical analysis of the data will be performed at a later stage.

Table 2.2: The results from the sweet bait route in Sebangau

	Burned area	Camp	Railway	Standard Forest	Riverside	Batgaps	Standard forest	Canals
Traps	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Total individ.	282	24	46	28	91	27	46	27

Escapes	4	2	0	0	2	2	0	1
Recaptured	6	0	0	0	1	0	0	0
Inactive traps	4	0	0	6	0	1	8	12
Not marked	7	2	1	0	0		0	0
Days	10	10	10	10	9	9	9	9
Date from	10-9-2010	10-9-2010	10-9-2010	10-9-2010	30-9-2010	30-9-2010	30-9-2010	30-9-2010
Date to	19-9-2010	19-9-2010	19-9-2010	19-9-2010	8-10-2010	8-10-2010	8-10-2010	8-10-2010

2.3.3 Results using savory bait Sebangau

As mentioned before moths are attracted to sweet bait as well as savory bait. To test if the savory bait would attract moths as well one route was set up, using the same traps but with different bait. As a savory bait decayed chicken was used. The results of this route is shown in table 2.3 The numbers of moths collected on the riverside significantly attract attention compared to the other areas. A statistical analysis of the data will be performed at a later stage.

Table 2.3: The results from the savory route in Sebangau

	Riverside	Batgaps	Standard forest	Canals
Traps	**4**	**4**	**4**	**4**
Total individuals	343	14	35	53
Escapes	1	1	0	0
Recaptured	0	0	0	0
Days of inactive trap	2	0	0	0
Not marked	0	0	0	0
Days	5	5	5	5
Date from	8-10-2010	8-10-2010	8-10-2010	8-10-2010
Date to	13-10-2010	13-10-2010	13-10-2010	13-10-2010

2.4 Discussion Method Butterfly traps

1. In some traps traces of dead moths have been found. Mainly the remains (wings) of the smaller moths were found. As mentioned before, natural enemies of moths include bats and birds . Some of these enemies are able to enter these traps, and can possibly do damage or kill the moths. In some traps spiders, wasps and rhino beetles were found. On figure 6 traces of dead

Figure 6: Traces of a death moth in one of the traps

moths are shown.

2. in some plots like the standard forest, the traps were as good as empty most of the time. In some traps the bait had been taken by other animals than moths, which resulted in an empty plate were the bait should have been on. Taking the bait possibly could have caused movement to the traps. It could be that due to the movement moths that were in the traps escaped. This movement as well as the fact that there was no bait left in the trap to attract moths, influenced in the amount of moths found in these traps.

3. The time of emptying the traps might as well be an influence on the amount of moths. It had occurred that moths escaped from a trap. This was noticed when we came back to an empty trap, that had moths in it earlier.

4. Unfortunately the data collected during the first days of the survey, have been used as well. Because of too little experience in handling the traps and moths, some moths escaped. I was not experienced with handling moths, such as catching them and holding them. Due to this moths escaped which makes our data set not 100% accurate.

5. The bat population has drastically declined which might have been a lucky fact for the moths population. But because no research has been done before and after the bat numbers declined,, there is no proof the moth population has flourished.

2.4.1 Disadvantages using savory bait

1. The savory bait (decayed chicken) attracts flies which lay eggs (figure 8). As seen on figure 7 the traps are filled with flies, which makes catching or photographing the moths, almost undoable. Once the trap is touched all flies start flying which makes it hard to find the moths.

Figure 7: A Blendon trap filled with fly's

Figure 8: The bait plate filled with maggots

2. Each day Using decayed chicken is very unpleasant to work with, because of the smell of the decayed chicken.

3. Just as banana bait, decayed chicken also attracts other predators which disturb the implementation of the study. In this case only 2 traps were made inactive on the river side. It can be assumed that the offenders were birds of prey which destroyed the traps trying to eat the bait.

3. Method 2 Light trapping techniques

3.1 Introduction

Light trapping is the most often used technique in collecting moths.. The total catch by light trapping techniques depends more on the agility of the moths then on the absolute number of moths. The total catch of light trapping includes samples from moths that are in movement rather than true abundance. Therefore the number of moths caught by light trapping, is influenced by the weather as well as the abundance of moths. (2).

Moths are positively phototactic, which means that they are attracted by light. There is no definitive explanation for this fact but there are some interesting theories which could possibly be applied on what is found in Sebangau as well as Bawan. Moths possibly navigate by the brightness of the sky, and with that the position of the moon relative to the earth. Research has shown that moths might use a geomagnetic compass system to guide them during their flight paths. Until now no animal has been found that integrate moon position and geomagnetic compasses for orientation. (1) So a moth's attraction by artificial light could be due to his drive for orientation. Other theory's are:

- Moths are sensitive to wavelengths of lights like ultraviolet light. They will be more attracted by bright white light than to yellow light. (5)
- Moths use light as an escape mechanism. When a moth is disturbed it always tends to fly upwards towards the sky, and not downwards (where its darker). (5)

3.2 Method & Material

Moths are collected in the first hours of darkness during a fixed period of time with a so called 'white sheet light trap' (see figure 9). Different light bulbs are tested to see which one is the most effective. The light illuminates a white sheet of 2,5 by 1 meter. The light trap technique is shown on figure 9. The light is powered using a generator. In

Figure 9: The light trapping technique

Bawan a fixed time period of 45 minutes (from 19.00-19.45 hours) is enough to attract a relevant set of species. 15 minutes after the lamp is turned on, the moths that land on the sheet are photographed (figure 10). In Sebangau the lighting time was 45 minutes to 120 minutes to attract a relevant set of species. In Bawan a typical Halogen lamp (construction lamp) of 500 watt is used. In Sebangau a power saving light bulb (Mercury vapour lamp) of 175 watt (representing 225 watt) is used. In Sebangau there is no permission to use killing-jars which are used in most light trapping researches. Thus, individuals are photographed using a digital macro-focus camera. This technique is used in several different areas. In Bawan, the technique is performed in the burned area 50 meters north from camp. This burned area has no trees, but a dense vegetation of mostly ferns that reach up to a height of 1.60 meters. In Sebangau the volleyball field and the railway is used. Both areas are chosen due to practical reasons. The volleyball field is close to the generator and the railway has a trolley to put the generator on.

Figure 10: A photograph of a moth on the white sheet

3.3 Several other methods

Due to the fact that this was a pilot study two other light trapping methods are carried out next to the light trapping technique that is discussed in the previous paragraph. The first one is netting with a torch. It is noticed that moths were frequently flying in front of head torches while walking through the forest in the night. Netting is a method that can be done in day-time as well as night time. This method needs skills to catch them, which can be gained by experience. Next to that, knowledge about the location on where to find moths, is of importance. After collecting the moths with netting, the moths can be photographed where after they can be released again. Bait or specific pheromones can lure moths to locations where after the moths can be netted(9). The second method is using the butterfly traps as light traps. Inside the butterfly traps 2 torches are situated (figure 11). The traps are closed on the bottom so the moths cannot fly into the traps. It is intended that the moths land on the outside of the trap on the luminous meshed gauze. Due to the low frequency of application of these techniques, the results are negligible. Also due to weather related factors some of these techniques are stopped early.

Figure 11: A butterfly trap with 2 torches inside

3.4 Results

3.4.1 Results Bawan

Table 3.1 shows the results from the light trapping technique based on the number of pictures taken. However the number of pictures is not representative for the number of moths that are drawn to the sheet. A statistical analysis of the retrieved data will be performed at a later stage. The results are from the light trapping technique in the burned area using a typical Halogen lamp (construction lamp).

Table 3.1: Results of the light trapping technique using the Halogen lamp (in the burned area)

Date	13-8-2011	14-8-2010	16-8-2010	17-8-2010	21-8-2010	24-8-2010	25-8-2010	30-8-2010
Number of pictures	36	114	56	47	37	22	19	12
Time from	7.05 PM	7.03 PM	7.00 PM	7.05 PM	7.09 PM	7.06 PM	7.00 PM	7.02 PM
Time to	7.47 PM	7.50 PM	7.45 PM	7.50 PM	8.04 PM	7.51 PM	7.44 PM	7.47 PM
Total minutes	42	47	45	45	45	45	44	45

3.4.2 Results Sebangau

Table 3.1 shows the results from the light trapping technique based on the number of pictures taken. However the number of pictures taken made are not representative for the amount of moths that were drawn to the sheet. A statistical analysis of the retrieved data will be performed at a later stage. The results in table 3.2 are from the light trapping technique on the railway using a Mercury vapour lamp. The results in table 3.3 are from the light trapping technique on the volleyballfield using a Mercury vapour lamp.

Table 3.2: Results of the light trapping technique using a Mercury Vapour lamp (on the railway)

Date	11-9-2010	17-9-2010	13-10-2010	TOTAL
Number of pictures	11	17	16	**44**
Time from	7.09 PM	6.53 PM	6.19 PM	
Time to	7.47 PM	8.52 PM	6.42 PM	
Total minutes	38	119	23	**180**

Table 3.3: Results of the light trapping technique using a Mercury Vapour lamp (On the volleyball field)

Date	7-10-2010	11-10-2010	13-10-2010	TOTAL

Number of pictures	2	97	120	**219**
Time from	7.00 PM	7.00 PM	7.00 PM	
Time to	7.47 PM	7.44 PM	8.16 PM	
Total minutes	47	44	76	**167**

3.6 Discussion Method 2 Light trapping techniques

An important subject of discussion is that sample selection from light trapping is more selectively than randomly. The sample selection is more selectively due to the choice of location and lighting. Though this counts for every other field method in animal ecology. This is also one of the reasons for combining two methods to include moths that are attracted to bait as well as light. Another subject of discussion is that a light trapping technique attracts moths from a distance, so that samples are diluted to an unknown degree by specimens not native to the local communion. Also the effective attraction radius depends on habitat structures such as vegetation density. (2) Next to these criticisms we will go through different factors that can cause disruption in the light trapping technique.

1. Light pollution

Apparently night lighting increases insect mortality as in artificially lit areas, moths are more vulnerable to predation by birds and bats. This applies to moths as well as the moth larvae. There is not enough research done on how artificial lit areas effect the diversity of Lepidoptera in a specific area, and therefore more research is recommended. (10)

2. The moon

On the nights before, during and after full moon, moths seemed to have no interest in the white sheet whatsoever. This could be due to the moths geomagnetic compass which is discussed in paragraph 3.1. Therefore it may be concluded that the results found, only count for moth diversity and not moth abundance on the time when the research was carried out.

3. Collecting with no killing-jars

Outrop is not authorized to kill flora nor fauna in the Sebangau area or the Bawan area. In moth research it is common to work with killing jars, where after moths are identified using the moths itself. Within this research photographs were taken which led to the following problems:

1. Moths depart before a photograph is taken. The number of escaping individuals is unknown.
2. The lighting-technique makes it hard to photograph due to lighting issues.

3. There is no possibility for accurate measurements on the thorax of the moths itself.
4. It is difficult to count moths while photographing because the moths come and go.

4. Absence of females

Light-trapping methods only attracts males. Females prefer to sit in the shelter of the vegetation. Despite this it can be assumed that when males are present in a certain area, females are present too. (11)

5. Criticisms on the materials

The generator that was used in Bawan was the main generator in camp. This meant that every day when the light trapping started, all other researchers in camp were restricted in the use of electricity. This was not a huge problem but is not ideal for future research. It is advised to purchase a generator that can specifically be used for light trapping.

6. *Burnt individuals*

In Bawan a Halogen lamp (construction lamp) of 500 watt is used. The lamp heats up during the hours in use which might affect the attraction of moths. Next to that, some individuals are more attracted to the light itself than to the sheet which results in burnt individuals.

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