

**STUDY ON PRAYING MANTIS (INSECTA:  
MANTODEA) IN BUKIT PITON FOREST  
RESERVE, LAHAD DATU, SABAH**

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**UMS**

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THE DEGREE OF MASTER OF SCIENCE**

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
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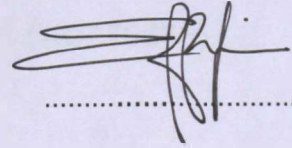
  

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## ABSTRACT

Borneo is an island with the highest mantodean diversity. However, information on praying mantis is still lacking from many parts of Borneo including Sabah. More information is needed regarding taxonomy, diversity and ecology of this fascinating insect. This study aimed to investigate the diversity and ecology of praying mantis in Bukit Piton Forest Reserve, Lahad Datu, Sabah. The study area located in the Northern part of Borneo, is a disturbed forest due to logging activities and forest fires in the past. Currently BPFR is undergoing forest restoration for the past few years. Twelve sampling sessions have been conducted over a period of 12 months. In total, 144 sampling days and nights been carried out by using light trap, baited trap and manual searching at six selected sites. A total of 187 individuals comprising 5 families, 16 genera and 19 species have successfully been collected. The collected mantises represent 16.1% of species that exist in Borneo. Mantidae was the dominant family accounting 53% of the total species and 36.4% of the total individuals followed by Hymenopodidae (32%, 14.4%), Iridopterygidae (5%, 27.3%), Tarachodidae (5%, 14.4%) and Liturgusidae (5%, 7.5%). Interestingly, the dominant species *Tropidomantis tenera* that made up 27% of the total individuals belongs to the family Iridopterygidae. Overall, the diversity indices showed that the praying mantis in the area was moderately diverse. Six singletons recorded in this study may signify rare or endangered status of the aforementioned mantis species. A comparison between disturbed forest (BPFR) and undisturbed forests (DVCA, MBCA and ICCA) was discussed in this study. The ongoing climate change and deforestation activities may have affected the diversity and abundance of mantis in BPFR but is not known since little attention is given to this fascinating insect. Pearson's correlation analysis was performed to investigate the relationship between environmental factors and species richness of praying mantis in the study area. The study revealed no significant correlation ( $p > 0.05$ ) between species richness of mantis and the studied factors (temperature, relative humidity and rainfall). Based on the biotic data, the sampling sites have low vegetation coverage and mainly dominated by trees with less than 5 cm of DBH. Meanwhile, no seasonal pattern detected on the overall mantis species collected. However, a particular pattern was observed during the wet season between *Tropidomantis tenera* and rainfall showing a significant positive relationship. Yet, the overall abundance of mantis species as compared to the wet and dry season did not show a clear seasonal pattern. These findings encouraged further samplings to probe into the occurrence of seasonal pattern of mantis species in BPFR. In this study, aspects such as inconsistent weather condition, availability of food resources, predation risk, density of vegetation coverage and size of trees might influence the abundance and species of mantis during the sampling. The information of mantis gathered from this study will serve as primary evidence of species found in the area and shall provide baseline information for future research. In general, Bukit Piton is suggested to be a potential habitat for mantis persistence. It is hoped that the restoration of Bukit Piton Forest Reserve would re-established the area into an excellent habitat for diverse mantis species.

## ABSTRAK

### KAJIAN MENTADAK DI HUTAN SIMPAN BUKIT PITON, LAHAD DATU, SABAH.

Borneo merupakan pulau yang mempunyai kepelbagaian mentadak tertinggi. Namun, maklumat berkaitan mentadak sangat kurang di Borneo, termasuk di Sabah. Maklumat berkaitan taksonomi, kepelbagaian dan ekologi tentang serangga ini perlu diperbanyakkan. Kajian ini bertujuan untuk menyiasat kepelbagaian dan ekologi mentadak di Hutan Simpan Bukit Piton. Kawasan ini yang terletak di Utara Borneo, adalah hutan terganggu akibat aktiviti pembalakan dan kebakaran hutan di masa lalu. Sejak beberapa tahun yang lalu, aktiviti restorasi di kawasan ini giat dilakukan. Kajian ini melibatkan 12 sesi persampelan dalam tempoh 12 bulan. Sejumlah 144 hari persampelan telah dilakukan pada waktu siang dan malam menggunakan kaedah perangkap cahaya, perangkap berumpan dan pencarian secara manual di enam kawasan yang terpilih. Keseluruhannya, 187 individu mantis merangkumi 5 famili, 16 genera dan 19 spesies telah berjaya dikumpul. Mentadak yang telah dikumpul mewakili 16.1% spesies di Borneo. Famili Mantidae yang dominan merangkumi 53% daripada jumlah spesies dan 36.4% daripada jumlah individu yang terkumpul. Ini diikuti oleh famili Hymenopodidae (32%, 14.4%), Iridopterygidae (5%, 27.3%), Tarachodidae (5%, 14.4%) dan Liturgusidae (5%, 7.5%). Menariknya, spesies dominan *Tropidomantis tenera* yang merangkumi 27% daripada keseluruhan individu merupakan famili Iridopterygidae. Hasil daripada analisis indeks kepelbagaian menunjukkan kawasan ini mempunyai kepelbagaian mentadak yang sederhana. Kebarangkalian enam singletons yang direkodkan dalam kajian ini mungkin spesies yang jarang ditemui atau terancam. Perbandingan di antara hutan terganggu (BPFR) dengan hutan tidak terganggu (DVCA, MBCA dan ICCA) turut dibincangkan dalam kajian ini. Perubahan iklim dan juga aktiviti kemusnahan hutan mungkin telah memberi kesan terhadap kepelbagaian dan kelimpahan serangga ini namun ianya tidak diketahui kerana kurang perhatian terhadap serangga ini. Analisis korelasi Pearson bagi mengkaji hubungan di antara faktor persekitaran (suhu, kelembapan dan hujan) dengan kekayaan spesies mentadak telah dilakukan. Walau bagaimanapun korelasi di antara kekayaan spesies mentadak dengan faktor-faktor yang dikaji adalah tidak signifikan ( $p > 0.05$ ). Berdasarkan data biotik, kawasan kajian ini mempunyai litupan vegetasi yang rendah dan didominasi oleh pokok bersaiz kurang daripada 5cm DBH. Kajian juga menunjukkan spesies mentadak yang terkumpul tidak mempunyai corak bermusim. Hanya satu corak dapat diperhatikan pada *Tropidomantis tenera* di mana terdapat hubungan korelasi ( $p < 0.05$ ) di antara spesies ini dengan taburan hujan pada musim hujan. Namun, kelimpahan bagi keseluruhan mentadak di kawasan ini tidak menunjukkan corak bermusim yang jelas pada musim kering dan musim hujan. Adalah diharapkan hasil kajian ini dapat menggalakkan kajian lebih lanjut tentang corak bermusim spesies mentadak di BPFR. Aspek seperti keadaan cuaca yang tidak konsisten, sumber makanan, risiko pemangsa, ketumpatan litupan vegetasi dan saiz pokok mungkin telah mempengaruhi kepelbagaian dan kelimpahan mentadak yang diperolehi waktu persampelan. Maklumat mentadak yang diperolehi daripada kajian ini adalah bukti utama spesies yang ada di BPFR dan menjadi sumber untuk rujukan kajian mendatang. Keseluruhannya, Bukit Piton dicadangkan sebagai habitat yang berpotensi bagi kelangsungan mentadak. Semoga restorasi Hutan Simpan Bukit Piton akan dapat memulihkan kawasan tersebut agar dapat menjadi habitat yang lebih baik bagi pelbagai spesies mentadak.

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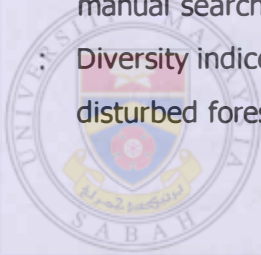
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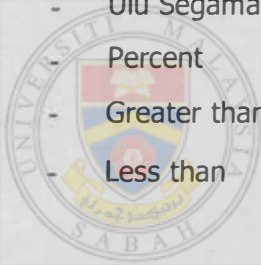
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## LIST OF SYMBOLS AND ABBREVIATIONS

BPFR	-	Bukit Piton Forest Reserve
°C	-	Celsius
cm	-	Centimetre
DBH/dbh	-	Diameter at Breast Height
DVCA	-	Danum Valley Conservation Area
F.R.	-	Forest Reserve
ICCA	-	Imbak Canyon Conservation Area
ITBC	-	Institute Tropical Biology and Conservation
IUCN	-	International Union for Conservation of Nature
MBCA	-	Maliau Basin Conservation Area
mm	-	Millimetre
UMS	-	Universiti Malaysia Sabah
USM	-	Ulu Segama-Malua
%	-	Percent
<	-	Greater than
>	-	Less than



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# CHAPTER 1

## INTRODUCTION

### 1.1 Study Background

The order of Mantodea is an interesting group of predatory insects with various forms of mimicry and mimesis. Mantis or widely recognized as 'Praying Mantis' is an insect classified under the order Mantodea of class Insecta in phylum Arthropoda (Prete *et al.*, 1999; Sureshan, 2009). Distinctively, mantises are easily recognised by their highly specialised raptorial forelegs and a triangular mobile head that can rotate 180 degrees (Helmkamp *et al.*, 2007; Ghate *et al.*, 2012). These fascinating insects are noted for their peculiar habits of prey capture, camouflage and cannibalistic sexual behaviours (Mukherjee *et al.*, 1995; Ghate *et al.*, 2012).

Tropical regions are believed to hold majority of mantis species (Rivera & Svenson, 2014). Although insects of this order occupy various habitats, they are mainly found in warm and moist climate of tropical rain forests (Mukherjee *et al.*, 1995). Tropical rain forests harbour millions of animal and plant species despite covering only 7 percent of Earth's land surface. According to Vogt (2013), the most numerous group of animals that occupy every level of the rainforests are insects. There are 3 main regions of tropical rainforest, which are in Central and South America, West and Central Africa, and Southeast Asia.

Southeast Asia is recognized as a biodiversity hotspot for Mantodea (Rivera & Svenson, 2014). However, recently Pfeifer *et al.*, (2016) stated that Southeast Asia has the highest rate of lowland forest loss of the entire tropical region with logging and deforestation as major drivers. Therefore, it is expected that lowland rainforest will cease to exist within the next decade due to human activities (Langner, 2009) if prevention measure of protection is not taken.

As a result of logging activities, the structure of rainforest communities may significantly change, thus leading to loss of species (Clearly *et al.*, 2009). In addition, a large-scale conversion of rainforest to oil palm plantations caused major biodiversity declination in Southeast Asia (Lucey *et al.*, 2014). Hence, aside from damaging the rainforest habitat, these large scale agricultural activities will threaten the wildlife that depend on it.

Borneo represents an island with one of the still remaining largest tropical rainforests in Southeast Asia (Langner, 2009). As mentioned by Rivera and Svenson (2014), there are approximately 2400 described species of praying mantis scattered around the world. So far, Borneo is noted as the island with the highest mantodean diversity with 118 confirmed species known to date (Schwarz & Konopik, 2014).

Borneo is located in the equatorial region of the Pacific Ocean and the third largest island in the world. Three nations; Brunei Darussalam, Indonesia and Malaysia divide the island into three territories. The Malaysian region of Borneo is further divided into two states, Sabah and Sarawak (Persoon & Osseweijer, 2008).

In Malaysia, Sabah is the second largest state, which occupies the northern part of Borneo. As stated by Gunggut *et al.*, (2014) the forest of Sabah is mainly of dipterocarps. Unfortunately, Sabah famously known as Land Below the Wind had experienced a massive loss of forest cover between 1970s and 1980s. An increased in forest exploitation had resulted in rapid deforestation. Unsustainable logging and agriculture plantation activities are clearly the main cause of a great reduction within a short period of time in forest loss and degradation (Gunggut *et al.*, 2014). The loss of forest is a huge concerned since forests are home to various living organism and the most vital environment for species survival.

The great increase in the disappearing of rainforest may threaten the survival of wildlife. As there is still lack of research on mantis especially in Sabah, study on praying mantis is an opportunity to gather more information on these fascinating insects. Currently, there might be mantises that faced extinction or become endangered due to the destruction of forest in the past. Without a proper research the status of the mantis species will remain unknown and efforts to protect the

species could not be carried out. Furthermore, with little research, no comparison can be made in the future. To conduct a conservation activity, it is important to understand the environmental parameters that are conducive for praying mantis survival.

## **1.2 Research Justification**

Literatures published related to mantis in Borneo are still insufficient. Due to their solitary lifestyle and cryptic behavior, diversity of this remarkable insect is frequently under-appreciated. Despite being noted as the island with the highest mantodean diversity, praying mantis in Borneo is still poorly studied. Nonetheless, studies on praying mantis on certain aspects such as ecology, behavior and physiology received more attention but only to focus on certain species of mantis (Rivera & Svenson, 2014). Apart from that, there are very limited sources of reference to understand their habitats and ecology. Hence, further attempt on field sampling and collection of praying mantis will provide more information on their distribution, habitat preference and ecology.

This research is the first attempt to study diversity and ecology of praying mantis on a long term basis in Borneo. Hence, this study will help to expand the knowledge of their diversity and ensure that their population are well-conserved in the near future. Furthermore, this study may provide an interesting information as it is conducted in a disturbed forest that is currently undergoing reforestation. In addition, baseline data collected in Bukit Piton Forest Reserve will enable comparative studies in the future when the forest are fully restored.

## **1.3 Objectives**

The objectives of this study are as follows:

1. To study the diversity and composition of praying mantis in Bukit Piton Forest Reserve.
2. To determine the relationship between environmental factors and species richness of praying mantis.
3. To ascertain seasonality of praying mantis species.
4. To provide and update the checklist of praying mantis in Bukit Piton Forest Reserve.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction to Mantodea

Mantodea is a group of predatory insect with an excellent camouflage ability that often mistaken with other elongated insect such as grasshoppers (Orthoptera) and stick insects (Phasmatodea). These carnivorous insects are better known as praying mantis due to their notable raptorial forelegs (Prete *et al.*, 1999) that folded under their head when hunting. In fact, the Greeks called them 'Mantes' which means prophet or seer (Agudelo *et al.*, 2007; Watkins & Bessin, n.d.) because the pose resemble praying position (Sureshan, 2009). In Asia especially China and Japan mantis became a symbol of strength, courage, and boldness due to their willingness to attack animals that are of equal or larger in sizes (Prete *et al.*, 1999). In mantodea, cannibalism applied to most of the species (Battiston *et al.*, 2010) and sexual cannibalism is a common behaviour of praying mantis with the female usually cannibalized the male during mating. However, despite their spectacular appearances, this short description is all that most people know about mantises.

During prey-capture, mantises can remain completely motionless for hours with only the mobile head move to watch for any disturbance in the surrounding area and to alert for nearby prey that serves as food (Mukherjee *et al.*, 1995; Sureshan, 2009; Ghate *et al.*, 2012). Mantis usually proceed slowly towards the prey and ambush when it is within grasping distance (Mukherjee *et al.*, 1995). This method of capturing prey is a remarkable predatory behaviour of praying mantis. Mantis is also a sedentary and highly cryptic insect that often mimic parts of vegetation in order to blend well with the background (Rivera and Svenson, 2014). Therefore, mantises are often seen on flowers, leaves, twigs, barks and grasses (Mukherjee, 1995). Their ability to highly camouflage made them undetectable to prey as well as predators.

These forms of mimicry increase the chance of prey-capture but made praying mantis difficult to observe and collect in the field.

Mantises are carnivorous insect that can consume arthropods in a smaller or similar size (Sureshan, 2009). In the arthropod community, mantises are known to be the top predators (Helmkampf *et al.*, 2007). Their role as predators play an important part as a natural control of insect pests (Mukherjee *et al.*, 1995). However, a recent study by Nyffeler *et al.*, (2017) shows the threat mantises pose to some bird species and was advised to be cautious when releasing mantises for pest control.

## **2.2 Diversity and Distribution of Mantis**

This captivating group of predatory insects can occupy various habitat (Mukherjee *et al.*, 1995; Agudelo *et al.*, 2007). According to Helmkampf *et al.*, (2007) mantis is mainly distributed in the tropical and subtropical region. In addition, Agudelo *et al.*, (2007) stated that a few groups of mantises are found living in dense tropical rainforest, whereas others inhabit arid forests and deserts from Africa to Australia. It is also found that praying mantis reside in many of the temperate zones such as Southern Europe, North America, Canada and South Africa. Accordingly, region with the highest species richness are African forests and savannahs, followed by rain forests of Southeast Asia (Helmkampf *et al.*, 2007).

Currently, the number of praying mantis species identified throughout the world is approximately 2400 (Erhmann, 2002; Otte & Spearman, 2005; Rivera & Svenson, 2014), out of which 118 confirmed species were discovered in Borneo (Schwarz & Konopik, 2014). To date, Borneo has been recognized as the island with the most diversified praying mantis fauna (Schwarz & Konopik, 2014). The first data representing species of mantis recorded in Borneo was reported by Erhmann (2002) which stated that there are 102 species of mantis throughout the island. However, very few studies had been conducted on mantis diversity to update the number of species in Sabah and other states in Borneo. Recently, there were several studies in Sabah which had been conducted at the areas such as Danum Valley Conservation Area, Maliau Basin Conservation Area, Imbak Canyon Conservation Area, Gomantong Virgin Jungle, Sukau Village and Muaya Rainforest Research and Education Centre (Lavinia, 2013; Ling *et al.*, 2013; Nurain, 2017). For example, a study conducted by

Ling *et al.*, (2013) at three sites namely Danum Valley Conservation Area, Gomantong Virgin Jungle, and Sukau Village concurred there were 38 species in those areas.

## 2.3 Taxonomy

### 2.3.1 Classification of Mantis

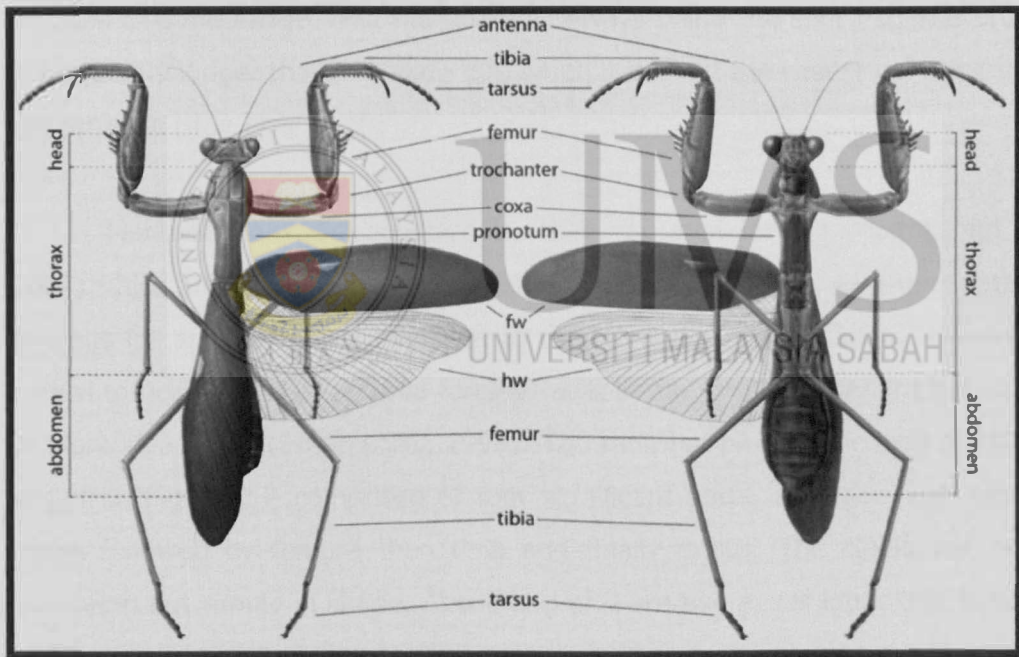
Mantis belongs to the order of Mantodea in the animal kingdom. It falls under the phylum of Arthropoda and the class Insecta. There are 15 families of Mantodea as stated by Erhmann (2002). So far, the largest family of the order Mantodea is Mantidae with 21 subfamilies recognized (Ramsay, 1990; Prete *et al.*, 1999; Patel and Singh, 2016). However, it is still debatable that this family consist of almost 50% of the total mantises described to date (Patel and Singh, 2016). With a very diverse in appearance, Mantidae consist of small to large-sized mantises (Erhmann, 2002). The classification from kingdom to family according to Agudelo *et al.*, (2007) is as shown in Table 2.1.

**Table 2.1: Classification of mantis from Kingdom to Family**

<b>Kingdom</b>	Animalia
<b>Phylum</b>	Arthropoda
<b>Class</b>	Insecta
<b>Order</b>	Mantodea
<b>Family</b>	Acanthopidae Amorphoscelidae Chaeteessidae Empusidae Eremiaphilidae Hymenopodidae Iridopterygidae Liturgusidae Mantidae Mantoididae Metallyticidae Sibyllidae Tarachodidae Thespidae Toxoderidae

## 2.4 Morphology

As stated by Ramsay (1990), mantis classification is generally depending on the features of the forelegs, antennae, pronotum, compound eyes, and colour. Male can be identified through genital structure and wing venation. However, this method is seldom being used. As for female, the classification based on genital structures has not been applied at all. Probably the structures of genitalia for both male and female, and the details of wing venation may provide useful characters for higher classification although it is regrettable that such information is not available for most mantis species (Ramsay, 1990). According to Roy *et al.*, (1999), Mantodea are relatively large in size and more or less elongated in shape. Like other insects, there are three main body parts of praying mantis; the head, the thorax, and the abdomen as shown in Figure 2.1.



**Figure 2.1: Dorsal and ventral view of praying mantis**

Source: Brannoch *et al.*, (2017)

### 2.4.1 Body Parts

In general, the head of mantis is normally wider than longer (Roy *et al.*, 1999). It is triangular in shape with two compound eyes and three simple eyes (ocelli) that allow for binocular sight (Roy *et al.*, 1999; Helmkamp *et al.*, 2007). The compounds and ocellis eyes are always globular. However, the well developed compound eyes are

sometimes slightly conical, and generally elongated when the head is longer than wider. The ocellis are always arranged in the shape of an isosceles triangle and generally smaller in the female than in the male (Roy *et al.*, 1999). Mantises have fine and filiform antennae with numerous segments (Ramsay, 1990; Roy *et al.*, 1999). Other than that, mantises have typical orthopteroid mouthparts which is developed for biting and chewing (Ramsay, 1990).

The thorax of praying mantis is divided into 3 parts; prothorax, mesothorax and metathorax. Mantis has a typical elongated prothorax (Helmkamp *et al.*, 2007). In most species, the mesothorax and the metathorax are shorter than the prothorax (Roy *et al.*, 1999). However, the mesothorax is longer than the metathorax in some species, but often it is the opposite. The movable pronotum is attached to the mesothorax (Ramsay, 1990). The supracoxal sulcus divides the pronotum into a prozone and metazone, with the prozone always being the shortest. The pronotum is frequently longer than it is wide but, when it is short the widest point is usually in the prozone (Roy *et al.*, 1999).

Mantodea are characterized by their raptorial foreleg (Helmkamp *et al.*, 2007) which are used for seizing and holding prey. Morphologically the adaptation of forelegs for predation are significant to the Mantodea identification. However, it is critical to note that the raptorial forelegs adaptation for predatory are not exclusive to Mantodea alone (Prete *et al.*, 1999). The raptorial prothoracic legs of mantis as shown in Figure 2.2 comprised of four significant parts. It begins with elongated coxae followed by femora then tibia and finally tarsus. The coxae are naturally elongated but simple in shape. At the end of it are two apical lobes that is normally well developed and divergent. The next part after coxae are the trochantera. The trochantera is connected to femora which are always longer than the coxae. Towards the end of the femur at the last internal spines there is always femoral brush that consist of short and strong bristles in the shape of spatula used for cleaning the head (Roy *et al.*, 1999).