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Skin-piercing Blood-sucking Moths I: Ecological and Ethological Studies on *Calpe eustrigata* (Lepid., Noctuidae)

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1. Introduction

The Noctuid *Calpe [Calyptra] eustrigata* Hmps. was reported as a skin-piercing blood-sucking moth for the first time in Malaya (BÄNZIGER, 1968) and is so far the only lepidopteran proved to suck blood by means of a piercing act. A few field observations and the description of the piercing behaviour of caged moths were given.

Apart from a taxonomic study of the genus *Calpe* (BERIO, 1956), a single record (BÜTTIKER, 1969) and some notes on the moth's proboscis and possible evolutionary pathway (BÄNZIGER, 1970, 1971, 1972), to our knowledge no other data have been published on the moth after its description as a new species (HAMPSON, 1926). The life cycle is completely unknown. From the scanty museum specimens available, it appears that the species inhabits South and Southeast Asia.

A closely related, though less rare species, the fruit-piercing *C. thalictri* Bkh., has been used for a detailed study of the piercing mechanism likely to be adopted by *Calpe* (BÄNZIGER, 1970): the feeding methods turned out to be as unusual as the feeding habits. Little or nothing is known about other *Calpe* species.

C. eustrigata is not the only adult lepidopterous parasite of mammals. Lachryphagous ("eye-frequenting") moths feed as "marginal" parasites upon eye-secretions of ungulates, elephants and occasionally man (SHANNON, 1928; REID, 1954; BÜTTIKER, 1964, 1967; BÄNZIGER, 1966). *Arcyophora* species and the eulachryphagous Noctuid *Lobocraspis graseifusa* Hmps. which apparently feeds exclusively upon eye discharges, are suspected as vectors of eye diseases (GUILBRIDE et al., 1959; BÜTTIKER, 1964; BÄNZIGER, 1972). While no lachryphagous moth is able to suck blood by a piercing act, there are a number of facultative lachryphagous moths which lick up the blood freely present at wounds, or that excreted anally by mosquitoes (BÄNZIGER, 1968, 1972).

Because of the scientific interest in *C. eustrigata*, research [1] has been carried out to investigate different biological aspects of the species in Malaysia, Thailand, Laos and Indonesia (May 1971–May 1973). The first account presented here will be continued with a paper (in prep.) on the piercing mechanism and soon, it is hoped, with more information on the physiology, life cycle and medical importance of the moth.

2. Observation sites (Fig. 1)

Malaysia

National Zoo (a), Kuala Lumpur. Bordered on one side by rubber plantations and on the other by a sequence of fruit orchards, secondary evergreen rain forests, and finally, on the adjoining hills (up to 1630 m), primary evergreen rain forests. Regularly checked animals: 4 "dwarf" zebu *(Bos indicus)*, 3 nilgai *(Boselaphus*

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[1] Supported with a grant by the Committee for the Travel Grant of the Swiss Society of Natural Sciences.

tragocamelus), 10 black buck *(Antilope cervicapra)*, 4 sambar deer *(Cervus unicolor)*, 10 hogdeer *(Hyelaphus porcinus)*, 1 fallow deer *(Dama dama)*, 1 red deer *(Cervus elaphus)*, 5 dromedary *(Camelus dromedarius)*, 4 giraffe *(Giraffa camelopardalis)*, 2 pony *(Equus caballus)*, 3 zebra *(Equus* sp.*)*, 5 donkey *(Equus asinus)*, 4 Malayan tapir *(Tapirus indicus)*, 1 black rhinoceros *(Diceros bicornis)*, 2 Indian elephant *(Elephas maximus)*, 5 tiger *(Felis tigris)*, 10 Indian and African lion *(Panthera leo)*, 2 black bear *(Selenarctos thibetanus)*, 2 sun bear *(Helarctos malayanus)*, 1 dhole *(Cuon alpinus)*, as well as several raccoon *(Procyon* sp.*)*, otter *(Lutra* sp.*)*, kangaroo, cassowary, emu and various birds of prey.

Pakistani village near Sungei-tua (b). Similar situation to (a). Occasional checks of 30 water buffalo *(Bubalus bubalis)*, 20 zebu and goat *(Capra hircus)*.

Area of Kampong Cheh (c), 16 km S of Taiping. 11 sites with over 30 zebu and 20 goat near fruit orchards, paddy fields, rubber plantations and primary rain forest on adjoining hills (up to 1810 m) were checked.

Thailand

Tha Yai (d), 20 km N of Chumphon. Checked 3 work elephant in evergreen rain forest at the foot of hills.

10 km W of Sai Yok (e), 25 km NW of Kanburi. Checked 1 elephant in deciduous forest with much bamboo.

Chiengmai Zoo (f), near deciduous forest (for details of the numerous animals checked and type of vegetation see BÄNZIGER, 1972).

Laos

Ban Kok Ngiew (g), 14 km S of Luang Prabang. Checked 25 water buffalo, 6 pig, 2 pony at 6 spots adjacent the Kha Mu village, bordered by hills with pineapple, banana, rice fields and, higher up, by deciduous forest.

Negative findings

No *C. eustrigata* was found at 66 sites of 11 major areas (Fig. 1); in the Udjung Kulon Nature Reserve, W. Java, Indonesia; and in many localities in Thailand and Malaysia (details loc. cit.) where we studied lachryphagous moths which live in similar ecological niches along with *C. eustrigata*.

3. Biotope

C. eustrigata was found in two different climatic regions: constantly wet tropics (Malaya, S. Thailand) and tropical monsoon region (W. and N. Thailand, N. Laos). In Malaya the annual rainfall near the observation sites ranges from 1990 mm (Gombak, region of (a) and (b)) to 3400 mm (Taiping) but on hills near these it may reach 5000 mm (Maxwell Hills). Although occasionally there may be no rain for up to 14 days at the observation sites, dew forms virtually every night. In the

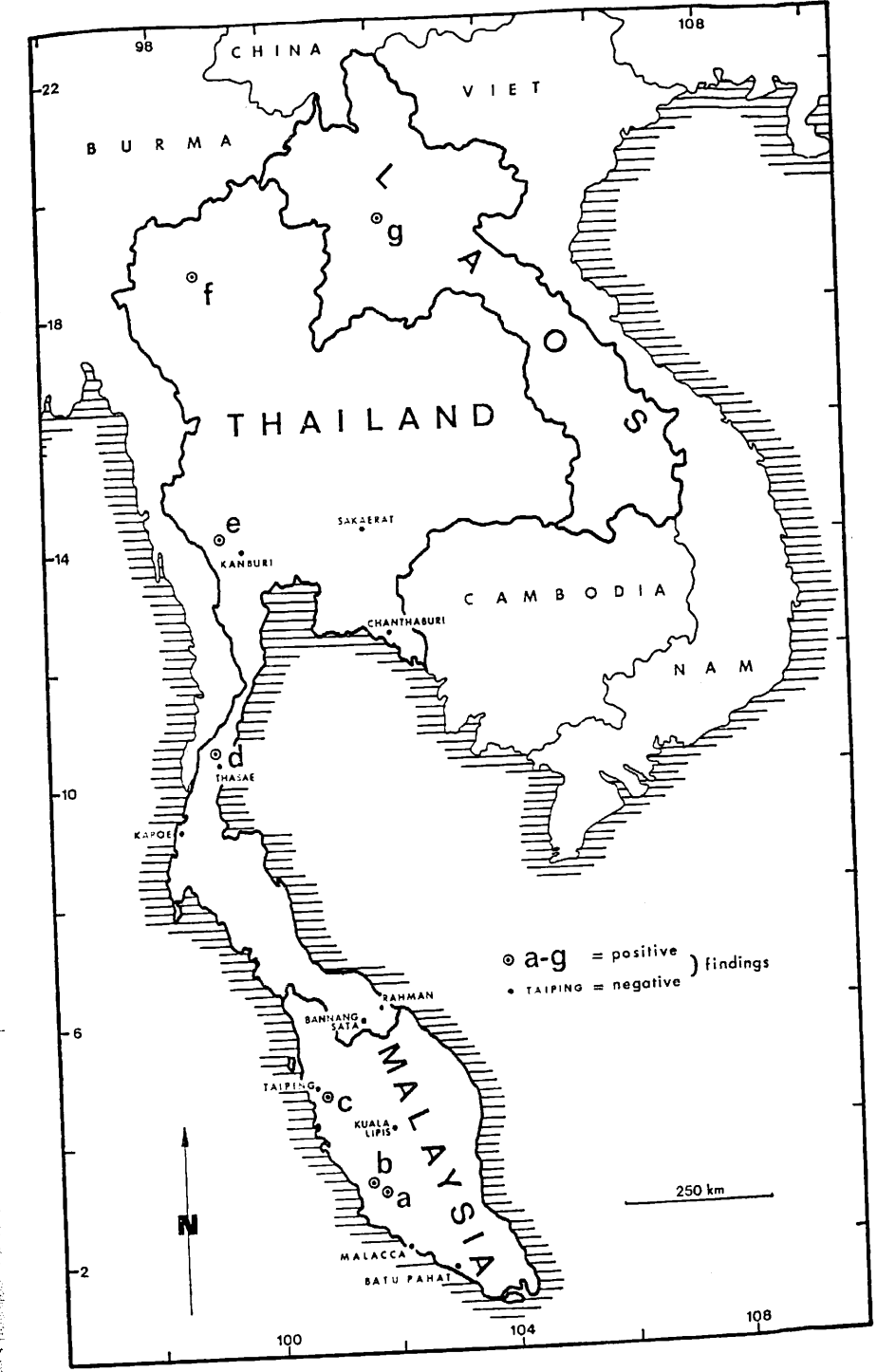


Fig. 1. Map of observation sites.

research area of the monsoon region the annual rainfall reaches 1200 mm (Chiengmai, near (f)) but from December to March there are only 5–15 mm/month though dew formation is regular from December through February (details loc. cit.).

The moth was found on lowlands and on intramontane plains (~ 300 m), always at the foot of hills of 1000–2000 m altitude. The type of vegetation was Evergreen Lowland Dipterocarp Rain Forest and Evergreen Hill Dipterocarp Rain Forest in Malaya and presumably S. Thailand (WYATT-SMITH, 1952). In W. and N. Thailand and N. Laos there was Deciduous (Monsoon) Forest with Evergreen Gallery Forest along its rivers (KÜCHLER and SAWYER, 1967; KHOMKRYS, 1972; OGAWA et al., 1961). Because of the lack of domesticated hosts no observations could be carried out on higher altitudes.

C. eustrigata was always found either in the forest or within a belt a few hundred metres from the forest and in all instances, the primary forest began no further away than 1 or 2 km from the sites. The moth attacked the hosts in dense forest with thick undergrowth (e) as well as in small clearings of the forest (d), or more open savannah-like areas (a) and (c), or on small pastures with a few shrubs (b).

C. eustrigata would appear to be distributed, at least as a blood-sucker, mainly in the region of the evergreen rain forest of Malaya and much less in the tropical deciduous forest.

4. Annual flight period and time of activity

Fig. 2 shows number, date and location of all records of *C. eustrigata* made during the present and the previous research.

At site (a), the presence of adult *C. eustrigata* throughout the year and the continuous flow of overlapping generations – as follows from the absence of any appreciable seasonal fluctuation – is remarkable when compared with lachryphagous moths. Although these exhibit habits comparable to those of *C. eustrigata*, all have marked seasonal population fluctuations (BÄNZIGER, 1972).

Site (b) was a good observation site in March and April 1967; however, in 1971, a moth was recorded during only 3 out of 12 nights of inspection; at (c) one specimen during 24 inspections and at (f) 3 during over 100 inspections.

Adults of *C. eustrigata* were found on the wing or feeding on hosts only at night and mainly during the first part of it (Fig. 3).

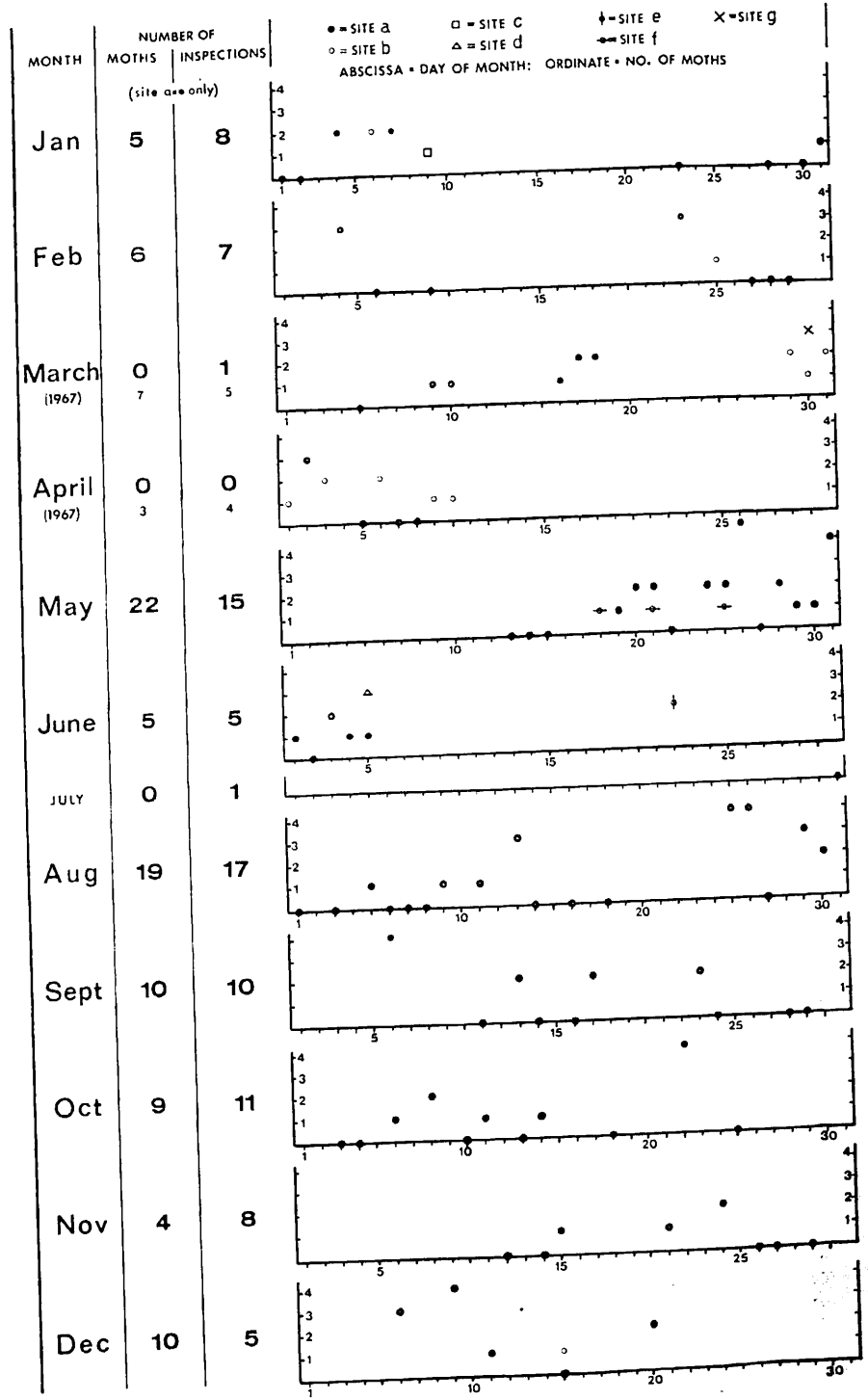


Fig. 2. Records of *C. eustrigata* on or near hosts, with special reference to observation site (a).

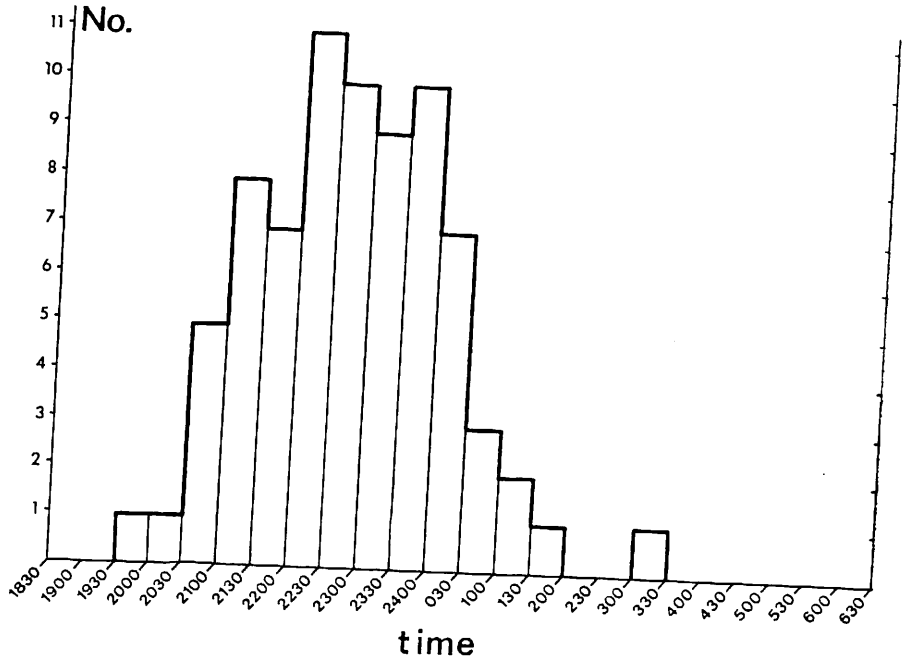


Fig. 3. Time of appearance of *C. eustrigata* on or near hosts at site (a). No. = number of specimens (not all specimens seen were recorded).

5. Flight patterns and alighting; condition, preference, etc. of feeding sites

When approaching a host from afar, the moth flew rapidly and generally high descending when near the host. At this point the flight became irregular, sometimes nearly hovering, very close to the host's side, often nearly touching it, rarely above it. This searching generally lasted from a few seconds up to many minutes depending on whether the host was of calm or excitable temperament.

C. eustrigata may circle around sleeping, dozing, grazing and walking hosts (feeding on such hosts: 20, 60, 10 and 10 %, respectively) but will not follow one which is running. It attacked legs (35 %), flanks (30 %), bellies (15 %), back (15 %), neck and throat (5 %) but never the head or the tail. When firmly clinging to the host, the moth could feed in any position: prone, supine, head up or down.

The feeding spots may be distinguished as: (i) normal healthy areas (Fig. 8 and 9); (ii) healthy but hairless areas, scars; (iii) excoriations (outer layer of the skin damaged, e.g. by intense scratching) (Fig. 6); (iv) blood-crusts of healing wounds and fissures in the skin (Fig. 7);

Table 1. Type of feeding spots on different hosts visited by *Calpe eustrigata*

	Normal healthy area (i)	Healthy but hairless area, scars (ii)	Excoriations (iii)	Fissures in the skin, crusts (iv)	Larger wounds etc. (v)
Sambar deer		[2]			[2]
Zebu	1				
Water buffalo	2				[6]
Nilgai antelope	4 (1)				
Malayan tapir	15 (3) [2]	7 (2)	14 (6)		16 (6)
Black rhinoceros	2	3 (2)	9 (2)	10 (3)	8 (3)
Indian elephant	1		1 (1)		

Plain numbers: number of observed cases (this may not equal the number of moths observed since some moths fed more than once and others did not settle); in round brackets: number of ascertained piercing; in square brackets: results from 1967.

(v) open, fresh or old sores, bleeding, purulent or serum exuding wounds (caused by mechanical damage, infections) (Fig. 10).

At site (a), rhinoceros and tapir had chronically type (iii), and the latter also type (v) caused by male fighting, while in the former fissures of the skin were found to be natural. The sambar has a bare area on the throat which is exposed especially in females during the rutting period; one individual had chronic wounds on the knees. From Table 1 it is evident that damaged skin areas were visited more than completely healthy ones. However, damaged skin was not always given preference to a healthy spot. In ten instances we noticed *C. eustrigata* feeding on or persistently attempting to pierce hosts with healthy skin nearby a host with wounds; and in seven cases a healthy spot was preferred to a wound on the same host.

A very important feature is that although blood or tissue exudates may be freely present at the piercing spot of an injured area, the moth nevertheless pierces into the tissue to suck blood, as is the case when it feeds from an intact spot. This has been verified by such criteria as: a) characteristic piercing behaviour (regular head oscillations with proboscis rather vertical, straight and fixed always at the same spot) which is clearly distinct from the "licking", non-piercing movement (head not oscillating, movements completely at random, proboscis inclined and moving around constantly (BÄNZIGER, 1970, and in prep.)); b) only the proximal part of the proboscis is visible, the distal part being inserted in the tissue (cf. Fig. 10); c) when the moth prepares to leave and fly away or when abruptly scared, sometimes the proboscis remains stuck in the tissue for a short moment, and the moth performs visible

attempts to free it; in a few instances it hung down on the proboscis for a fraction of a second.

While the rasping away of superficial cells and uptake of small amounts of fluid and decaying tissue from sores is common for short periods before the proper piercing act begins, we observed only twice a substantial amount of blood being imbibed from a wound without piercing. In a very few other cases the moth continued the piercing attempts for an unusually long period (over 30 min) at a particular spot without any success. All these cases appear to be due to the insect's physiological unfitness. Generally, if the piercing attempts were not successful after one minute at most, the moth changed its place or host. This happened very frequently.

In *C. eustrigata*, feeding lasts from 5 to 30 min; the average is about 12 min.

Except during strong rain and wind, the moth was seen feeding or flying during all weather conditions. The moth's reactions to light were similar to those of *L. griseifusa* (BÄNZIGER, 1972).

6. Hosts (Table 2)

So far *C. eustrigata* has been shown to be attracted to 10 mammal species. However, attacks proved successful with an actual piercing act taking place only on 6 species: Malayan tapir (Fig. 4, 8–10), black rhinoceros (Fig. 5–7), Indian elephant, nilgai antelope and, according to earlier records (BÄNZIGER, 1968), water buffalo and sambar deer. Zebu was attacked but piercing could not be proved. Red deer and fallow deer were pursued for minutes by the moth but, probably owing to their restlessness, no alighting occurred. Despite the presence of chronic sores on the knees of one sambar and its calm temperament, no *C. eustrigata* was seen to alight on this deer during the present research; in 1967, however, the moth was seen feeding repeatedly on it. No *C. eustrigata* was found on all other species checked (pp. 125/126).

The host's reactions to attacks of *C. eustrigata* vary individually and specifically but a slight rise in nervousness was noted in all host species. The elephant at (f) and the nilgai were often made nervous just by the simple circling of the moth around their body; the horse fly *Tabanus* sp.[2] caused no visible reaction when circling around the former at night. Tapir and rhinoceros generally remained calm. The hosts reacted more mildly when lying or, of course, when sleeping, under which circumstances the moth fed completely undisturbed. A specimen circled

[2] According to J. J. S. Burton, Cornell University, it is a new species which he will describe in a forthcoming paper.

Table 2. Hosts of *Calpe eustrigata*

	Total number of single cases	No alighting followed repeated landing attempts or moth collected before	Alighting took place
Artiodactyla			
Cervidae			
Sambar (*Cervus unicolor*)	6 [7]	6 [3]	[4]
Red deer (*Cervus elaphus*)	2	2	
Fallow deer (*Dama dama*)	2	2	
Bovidae			
Zebu (*Bos indicus*)	1		1
Water buffalo (*Bubalus bubalis*)	8 [15]	6 [9]	2 [6]
Nilgai (*Boselaphus tragocamelus*)	5 [1]	1 [1]	4
Perissodactyla			
Tapiridae			
Malayan tapir (*Tapirus indicus*)	63 [2]	11	52 [2]
Rhinocerontidae			
Black rhinoceros (*Diceros bicornis*)	34	2	32
Proboscidea			
Elephantidae			
Indian elephant (*Elephas maximus*)	8	6	2

Plain numbers: present investigation; in square brackets: investigation of 1967.

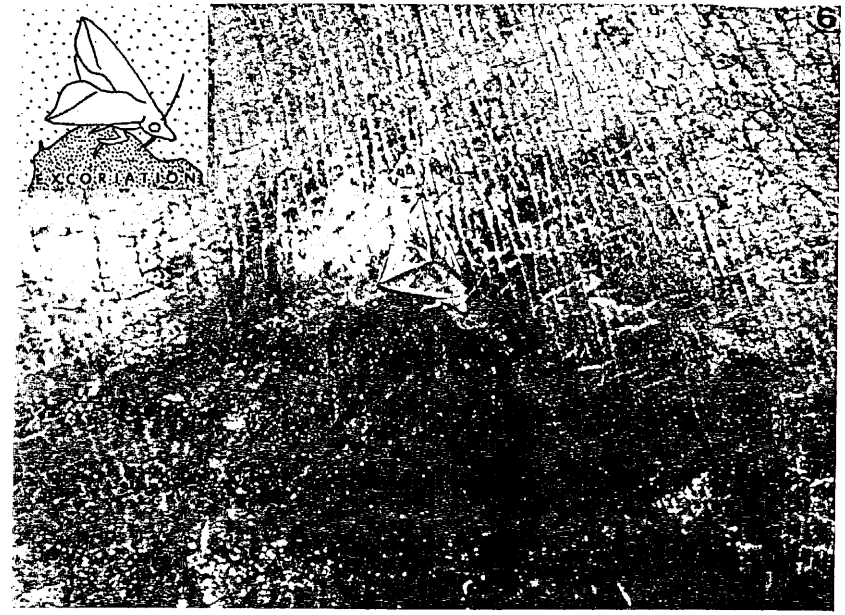
around, landed and performed piercing attempts on a resting but awake nilgai; some time elapsed before the host suddenly reacted violently and dislodged the moth, which presumably had just succeeded in piercing the skin.

The hosts' defensive reactions may include, besides those used against lachryphagous moths (BÄNZIGER, 1972), quivering the skin, rolling the body sideways on the ground, crushing the moth with the snout or the horns; elephants used a plant as a whip held in the proboscis or threw earth. However, apparently when hungry, the moth often persisted; in a few cases it happened that the moth remained clinging to a running tapir which was scared by our approach.

Hosts normally calm even in our presence became sensitive to us when a moth tried to feed or was feeding already on the host. This made observations very difficult.

Fig. 4. C. eustrigata probing on a Malayan tapir.

Fig. 5. C. eustrigata feeding on a black rhinoceros. Inserts drawn from the original colour negatives under magnification.



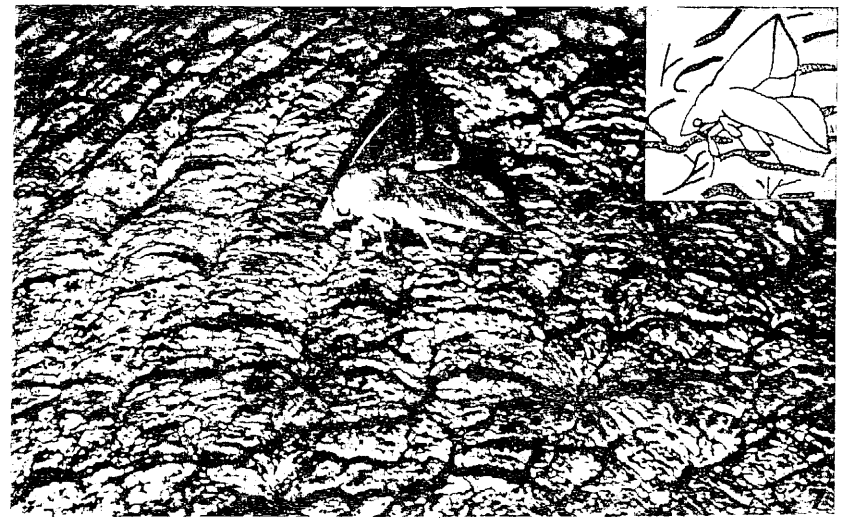


Fig. 6. C. eustrigata piercing at the edge of an excoriation on a black rhinoceros.

Fig. 7. C. eustrigata piercing into skin fissures of a black rhinoceros.

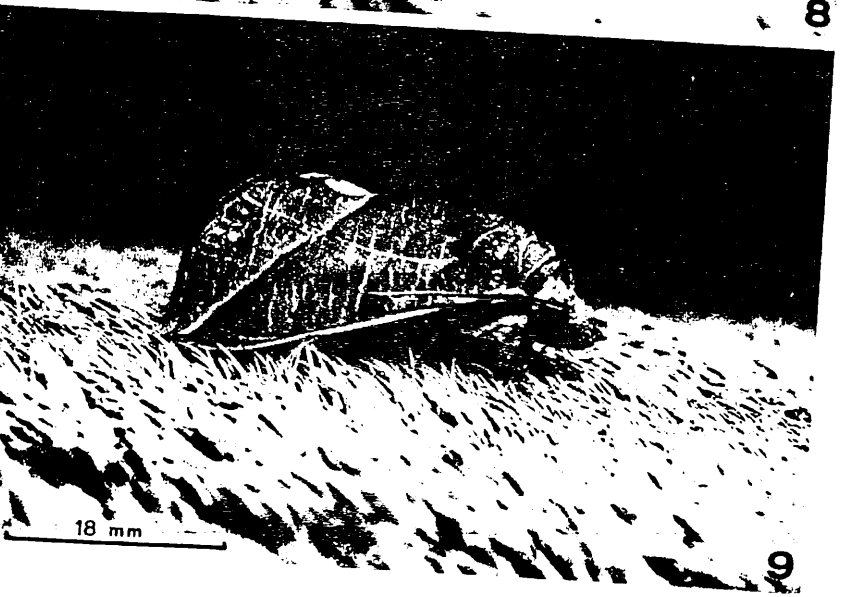


Fig. 8. *C. eustrigata* piercing a healthy spot on a Malayan tapir.

Fig. 9. Same as above but proboscis penetrating deeper.

Fig. 10. *C. eustrigata* piercing a sore of a Malayan tapir. 1/3 to 1/4 of the proboscis is inserted; the point of insertion is well visible.

Fig. 11. *C. eustrigata* piercing a guava fruit (experiment with a caged specimen).

7. Man as a host

From our observations and inquiries among residents, nothing definite can yet be said about man being attacked by *C. eustrigata* – or possibly an allied species – but this hazard is well possible though probably rare and localized. In captivity the moth attacked and pierced the author's skin on a few occasions, but the insect can be induced to do so more often by stimulation.

8. Role of foods other than blood

As a lepidopteran, *C. eustrigata* may be expected to feed upon nectar or fruit or different mammal body fluids. Despite regular checks, the moth has never been seen on flowers.

As the related species *C. thalictri* is a fruit piercing moth, check of fruit trees was emphasized. Several guava *(Psidium guajava)*, rambutan *(Nephelium lappaceum)* and wild fruit or berry bearing trees *(Vitex pubescens, Lea indica, Graevia tomentosa)* grew in or near the animal enclosures of site (a). The fruit orchards of site (a), (c), (f) and many other places, with rambai *(Baccaurea motleyana)*, lansa *(Lansium domesticum)*, mangosteen *(Garcinia mangostana)*, carambola *(Averrhoa carambola)*, rose-apple *(Eugenia jambos)*, custard apple *(Annona reticulata)* and rambutan were also inspected. Furthermore, at a number of nights guava, lansa, opened durian *(Durio zibethinus)* and mangoes (*Mangifera* sp.) were laid out on the fence of the tapir's enclosure (site (a)). Fruit-piercing moths, mainly *Othreis* sp., were often seen on

guava, rambutan and occasionally on the berries. However, we never saw any *C. eustrigata* on or near a fruit.

On the other hand, caged *C. eustrigata* liked to pierce and feed on guava (Fig. 11), mango, peach, mandarine, lansa, grape, apple, prune, and rose-apple.

Of the mammal body fluids (sweat, sebum, serum, saliva, eye-secretion, urine and dung), the first three are probably taken up in minor amounts when the moth palpates the skin of the host before the piercing act, while we have never seen the latter four being imbibed by *C. eustrigata*.

A specimen recorded by BÜTTIKER (1969) from former E. Pakistan was captured while reportedly flying away from (or near?) the eye of a cow (BÜTTIKER, pers. comm.). It is not known whether the moth was feeding but certainly neither behaviour nor feeding habits – as observed during the current and earlier research – nor the proboscis morphology (BÄNZIGER, 1972) are those of a lachryphagous species.

Remnants of fresh and old meat (horse, zebu), often smeared with blood, in the lion's and tiger's enclosures, fish and bruised fruit and vegetables in the otter's, bandicoot's, bear's and tapir's enclosures were regularly inspected as well, but we never saw any *C. eustrigata* there.

It should be mentioned that, although blood is generally taken by insects because of its content of protein, this is not necessarily so for *C. eustrigata*. There is some indication that this lepidopteran also holds an exceptional position in regard to its feeding physiology.

9. Sex ratio

The most intriguing finding about *C. eustrigata* is that we found exclusively males. This does not appear to be merely a matter of chance. The species was studied in 7 different regions from Malaysia to Laos during all months of the year. Females probably have different feeding habits.

10. Enemies

Several bat species, one of which was identified as *Rhinolophus malayanus* (site (c)), patrolled regularly the territory of the rhinoceros, tapir, water buffalo and zebu every night. The bats chased all Lepidoptera flying near the host, snatching away many before they were secured in our net. *C. eustrigata*, however, though it was often the aim of the bats, always managed to elude the aggressor with an abrupt turn in the line of flight. But after such an attack the moth was so frightened that it flew away in a zig-zag course without returning to the host. Another large bat species chased moths irregularly at site (f).

Fig. 12 and 13. C. eustrigata at rest resembles a shrunken leaf when seen from the side, or a bud when seen from above. Note the position of the antennae and the retracted fore legs.

11. Resting (Fig. 12 and 13)

In nature, no specimen – active or at rest – was found during the day. Caged *C. eustrigata* were at rest during daylight hours. The resting position is characteristic.

12. Discussion

The lack of female *Calpe eustrigata* in the ecological niche where the blood-sucking males feed is most striking – in mosquitoes and tabanids only females are blood suckers.

The absence of females in the biotope where males were found feeding hardly can be a mere chance (p. 138). Externally the females have nothing that would suggest different feeding habits from the males. It has been mentioned that *C. thalictri* is a fruit-piercing species and that

caged *C. eustrigata* males eagerly pierce at least 9 kinds of fruit, although we have never seen the moth do so in nature despite our specific search for such activity. Possibly it simply prefers blood when this is available in the neighbourhood. Females may well feed exclusively or at least mainly on fruit. In the field it was possible to check only 8 of the 86 cultivated (local and introduced) types of fruit (ALLEN, 1967) and only a few kinds of berries of the numerous jungle trees.

It is also possible that females may feed on a particular flower whose nectar is accessible only to a piercing proboscis like that of *C. eustrigata*. The carpenter bee *Xylocopa leucothorax*, for instance, is one of the few insects able to force its specially adapted proboscis into the nectar-holders of *Calotropis procera* (SCHREMMER, 1971).

The uptake of protein-rich fluids by the males alone occurs in several Lepidoptera. In the Geometrids *Hypochrosis hyadaria, H. flavifusata, H. iris, Nobilia turbata, N. obliterata* and the Pyralids *Filodes fulvidorsalis, Pionea aureolalis* Led., *Pagyda salvalis* Wlk. only males were observed imbibing protein-rich eye-secretions and, if available, the blood present at wounds or as blood droplets excreted anally by mosquitoes (BÄNZIGER, 1972). Females – and also males – of *F. fulvidorsalis* and other zoophilous Pyralids were found sucking nectar from mandarin flowers *(Citrus nobilis)*. On the other hand, in the Noctuid *L. griseifusa* both males and females visit eyes and the latter are predominant. In *Heliconius* butterflies, too, both sexes feed on a protein-rich food, pollen. This plays an important role in their reproductive and population biology (GILBERT, 1972). However, in *C. eustrigata,* it may tentatively be assumed that blood plays a role mainly as energy supplier for the male.

From the present investigation, it is clear that injured skin plays a relevant role for food-seeking *C. eustrigata* males; but, as a rule, blood is drawn by piercing the tissue even if it is freely available at the wound. Injured skin of types (iii), (iv) and (v) was visited in 58 cases, uninjured skin in 34 cases; but the ratio of ascertained piercing acts into injured and uninjured skin was 21 to 8. In the remaining 37 cases (balance 58–21) and 26 cases (34–8), the moth either did not succeed in piercing or circumstantial factors interrupted the piercing attempts or no evidence on whether the moth did or did not pierce was obtained. The high incidence of such "open" cases is due to the difficult working conditions in the field at night with either aggressive or timid animals.

Injured skin is probably more attractive because of its scent, and its tissue is more easily pierced. However, the abnormally abundant sores among the animals at site (a) might have influenced the ratio.

C. eustrigata differs distinctly from the above-mentioned blood-"licking" Geometrids and Pyralids, and from lachryphagous Noctuids, which are all wholly incapable of piercing both injured and uninjured skin. The feeding habits are closer to those of certain flies which draw blood from the crusts of sores, which they tear with their prestomal teeth, e.g. *Musca conducens* (PATTON, 1933) and in particular *M. crassirostris*, which is reported to be able to tear healthy skin (CRAGG, 1912). However, the mechanisms involved are wholly different from those of *Calpe*.

Several features suggest that in its way of feeding, *C. eustrigata* is a fairly recently evolved, somewhat clumsy sucker. The moth's size, light colour and conspicuous flight pattern alarm the host more than any other blood sucking insect, though it does not cause the panic which is said to be aroused by the buzz of warble flies. The moth's attempts to alight are often perceived even by elephants. Moreover, because of its size, the moth cannot advance into dense fur, which would also hinder the proper working of the piercing mechanism. The deep punctures by the large proboscis would be too painful for medium and small animals, e.g. most carnivores and primates, rodents, etc.; birds; amphibians and reptiles. The latter are also potential predators of the moth. Thus it has a limited host range comprising mainly large mammals of tolerant temperament, little sensibility and defence ability, and with sparse fur: tapir, rhinoceros and other large ungulates. The moth's predilection for spots which are easy to pierce, such as excoriations and fissures, the often-repeated piercing attempts, frequent change of piercing spots and host, all seem to corroborate further the view that the moth is a "novice" among blood-sucking insects. These considerations fit well into the hypothesis formulated previously that the skin-piercing blood-sucking feeding habit is the last stage in the evolutionary line from nectar-sucking, to fruit-piercing, to skin-piercing in Lepidoptera.

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Summary

1. The only known skin-piercing, blood-sucking lepidopteran adult is *Calpe eustrigata*, a scarce Noctuid, of which 90 adults were found at site (a) during 88 night inspections. Some 16 specimens were found at 40 further sites during over 100 inspections in Malaysia, Thailand and Laos (1971–1973).

2. The moth was found only near or in forests (mainly Evergreen Dipterocarp Rain Forest, less in Deciduous Forests) up to 350 m altitude.

3. Adults were on wing all the year round in quite constant numbers – unlike other zoophilous and fruit-piercing moths. Strictly nocturnal, *C. eustrigata* was

active from 20 to 02 h but mainly from 22 to 24 h. When at rest it resembles a dry leaf.

4. Hairless scars, excoriations, fissures in the skin, fresh or old sores with or without tissue fluids or blood were often but not always preferred to healthy skin. However, in order to suck blood the moth always *pierced* the tissue, even if blood was freely present at the wound. Average feeding duration was 12, maximum 30 min.

5. Hosts: Malayan tapir, black rhinoceros, Indian elephant, sambar deer, nilgai antelope, water buffalo, zebu, red deer and fallow deer (actual piercing act not yet proved for the last three). It is still an open question whether man is a host; if he is, this must be rare and localized.

6. Despite regular checks, we have never observed *C. eustrigata* in the open feeding on mammal eye-secretions, saliva, urine, dung, fresh or old fish or meat with or without blood; bruised fruit and vegetables; nectar of flowers or fruit on trees. Caged moths, however, pierced a variety of fruits.

7. No female was found on mammals. Like many lachryphagous and other zoophilous Lepidoptera, it may be phytophagous, e.g. fruit-piercing as the related *C. thalictri*.

8. Ethological and ecological features indicate that *C. eustrigata*'s feeding habits are a rather recent development probably derived from nectar-sucking via fruit-piercing feeding.

Zusammenfassung

1. Der stechend-blutsaugende adulte Nachtfalter *Calpe eustrigata* wurde während 25 Monaten in Malaysia, Thailand and Laos untersucht. Von dieser spärlich vorkommenden Noctuide wurden 90 Exemplare in 88 Nächten im Beobachtungsort (a) und 16 Exemplare in über 100 Nächten in weiteren 40 Orten gefunden.

2. Die Art wurde nur in oder am Rande von Wäldern (meist Immergrüne Dipterocarpaceen-Regenwälder, seltener Regengrüne Dipterocarpaceen-Wälder) bis auf 350 m Höhe beobachtet.

3. Adulte flogen von 20 bis 02 Uhr (am häufigsten zwischen 22 und 24 Uhr) und waren im Gegensatz zu anderen zoophilen und den früchtestechenden Lepidopteren, während des ganzen Jahres in ziemlich konstanter Zahl aktiv in (a). In Ruhelage gleicht der Falter einem trockenen Blatt.

4. Haarlose Narben, Abschürfungen, Hautrisse, frische oder alte Wunden mit oder ohne Gewebsäften oder Blut wurden der gesunden Haut oft vorgezogen. Der Falter stach jedoch ins Gewebe, selbst wenn Blut an der Wunde frei vorhanden war. Die Saugdauer war durchschnittlich 12, maximal 30 Min.

5. Wirte: malayischer Tapir, Spitzmaulnashorn, indischer Elefant, Sambarhirsch, Nilgauantilope, Wasserbüffel, Zebu, Rot- und Damhirsch (eigentlicher Stechakt bei den letzten drei noch nicht gesichert). Es ist noch unklar, ob der Mensch befallen wird.

6. Der Falter wurde nie an folgenden potentiellen Nahrungen beobachtet: Tränen, Urin, Kot und Speichel von Säugetieren; frischem oder altem Fisch oder Fleisch mit oder ohne Blut; zerquetschten Früchten und Gemüsen; Blüten oder Früchten auf Bäumen, die alle regelmäßig untersucht wurden. In Gefangenschaft sog der Falter aber an verschiedenen Früchten.

7. Alle gefundenen *C. eustrigata* waren Männchen. Entsprechend vielen lacriphagen und anderen zoophilen Lepidopteren könnte das Weibchen phytophag sein, z. B. früchtestechend wie die nahverwandte *C. thalictri*.

8. Ethologische und ökologische Eigenschaften in der Ernährungsweise von *C. eustrigata* deuten auf eine relativ junge Entwicklung hin, die sich wahrscheinlich von der nektarsaugenden über die früchtestechende Stufe ableiten läßt.

Résumé

1° Le seul lépidoptère connu perçant la peau et suçant le sang est *Calpe eustrigata,* qui a fait l'objet de recherches en Malaisie, Thailande et Laos de 1971 à 1973. De ce papillon nocturne peu fréquent il a été trouvé 90 adultes dans un site (a), au cours de 88 inspections, et 16 spécimens dans 40 autres sites à l'occasion de 100 inspections.

2° Cette espèce a été trouvée seulement à proximité ou dans les forêts (principalement dans les forêts humides à feuillage permanent de type Dipterocarp, et moins souvent dans les forêts mésophiles) jusqu'à 350 m d'altitude.

3° Au contraire des autres papillons zoophiles et fructivores, les adultes volent toute l'année en nombre à peu près constant. Strictement nocturne, *C. eustrigata* est actif de 20 h. à 2 h. du matin, mais surtout de 22 à 24 h. Au repos il ressemble à une feuille sèche.

4° Cicatrices glabres, excoriations, fissures de la peau, ulcérations fraiches ou anciennes avec ou sans exudat ou sang, sont souvent mais pas exclusivement préférées à la peau saine. Cependant, pour sucer le sang, ce papillon doit toujours percer la peau, même si du sang frais est présent au niveau de la blessure. La durée moyenne du repas sanguin est de 12 minutes avec un maximum de 30 minutes.

5° Hôtes: Tapir malais, rhinocéros noir, éléphant indien, sambar, antilope nilgai, buffle d'eau, zébu, cerf rouge et daim (actuellement les trois derniers hôtes ne sont prouvés avec certitude). La question est encore ouverte de savoir si l'homme est un hôte possible. S'il l'est, cela doit être de façon exceptionnelle et localisée.

6° En dépit d'observations rigoureuses nous n'avons jamais pu observer *C. eustrigata* dans les excrétats de mammifères: secrétions oculaires, salives, urine, faeces; ni dans les viandes ou poissons, frais ou décomposés, avec ou sans présence de sang; ni non plus dans les fruits blets, les légumes, le nectar des fleurs ou des fruits et la sève des arbres. En captivité cependant ce papillon perce la peau de différentes variétés de fruits.

7° Aucune femelle n'a été trouvée sur des mammifères. Comme beaucoup d'autres lépidoptères zoophiles ou lacrymophages, il est possible qu'elles soient phytophages, fructivores par exemple comme *C. thalictri.*

8° Les caractéristiques écologiques et éthologiques de *C. eustrigata* montrent que ses habitudes nutritives sont d'un développement plutôt récent, probablement dérivées d'un alimentation à base nectar en perçant la peau des fruits.

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Haemolytic Activity in the Blood Clot of *Aedes aegypti*

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Abstract

In the present study it was demonstrated that mosquito blood clots contain a haemolytic principle which achieves haemolysis of washed erythrocytes in an isotonic medium. Proteinases are thought to play a role in this process. No final proof could be given for the existence of phospholipase activity although some results suggest the presence of this group of enzymes.

Introduction

The knowledge of the physiology of blood digestion in haematophagous insects is of special interest in studies on host/parasite relationships. All pathogens transmitted by blood-sucking insects spend some time in the gut of their vectors and might be influenced by digestive processes.

One of the questions in blood digestion is the mechanism of the break-down of erythrocyte membranes, a process necessary for rendering the haemoglobin accessible to digestive enzymes such as proteinases. Haemolysis may be induced by various factors such as environmental changes, phospholipases or direct lytic factors. Lytic substances have been described in venoms (Condrea & De Vries 1965, Habermann 1972).

In order to obtain insight into the processes of blood digestion in mosquitoes, the haemolytic activity of the blood clot against washed erythrocytes was tested. In addition, attempts were made to identify a specific phospholipase which could indirectly induce haemolysis by forming lysolecithin. Phospholipase A and B have been previously described in mosquito homogenates, the highest activity being represented in larval stages (Rao & Subrahmanyam 1969 a + b, 1970). No data, however, exist on the occurrence of these enzymes in blood fed females.

Material and Methods

Aedes aegypti L., strain Segemaganga was used in this study.

Haemolysis

The method described by Lankisch and Vogt (1972) and by Vogt et al. (1970) was applied by using rabbit blood in an isotonic medium. The liberated haemoglobin was converted to cyano-methaemoglobin and measured photometrically at 540 nm. The effects were estimated as % haemolysis (Fig. 1). Fourty blood clots were used in a final volume of 5 ml erythrocyte suspensions.

A second assay system contained 0.5 ml of a 1 : 30 dilution (v/v) of erythocytes. The volume was made up to 3.5 ml with 0.01 M phosphate buffer pH 7.3 containing 0.15 M NaCl and 0.45 mM $CaCl_2$. This mixture, after addition of