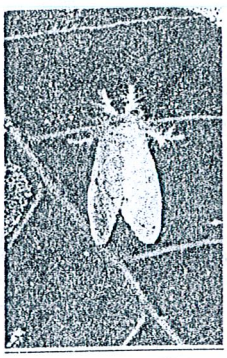
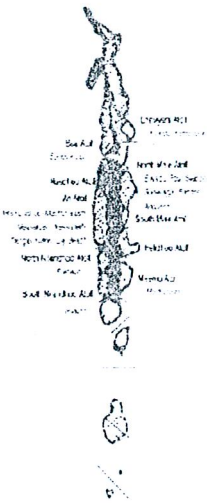




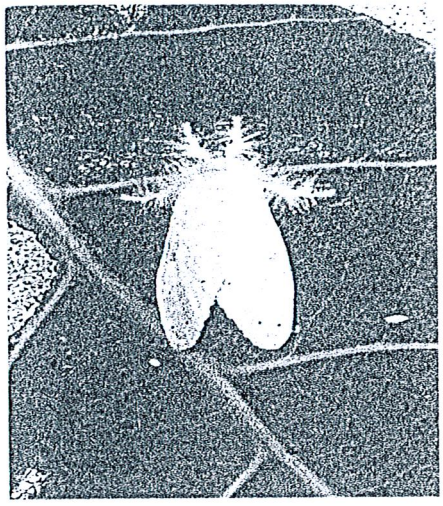
Impact of

Euproctis fraterna Moore (Lepidoptera: Lymantriidae) in the Maldives

and

suggestions for the development of control measures

Impact of *Euproctis fraterna* Moore (Lepidoptera: Lymantriidae) in the Maldives and suggestions for the development of control measures



(Approx 2 x normal size)

Wilco J.M.M. Liebregts
Eco-Consult Pacific
Suva, Fiji
www.ecoconsultpacific.com

CONTENTS

ACKNOWLEDGMENTS

I wish to thank the Minister of Fisheries, Agriculture and Marine Resources, Hon. Abdullah Kamaludeen for his continuing support to this project. Mr. Mohamed Zuhair, Executive Director, MFAMR, is very much thanked for his help. Ms. Aminath Shafia, Director of Agriculture, has been a driving force behind this project, and her support and assistance is acknowledged with appreciation and gratitude. The technical assistance provided by Messrs. Ismail Rasheed and Amir Ali, both staff of MFAMR, has been extremely helpful, and both are much thanked for their work and help. The advice and help of overseas colleagues Dr. Peter Maddison of Field Studies, New Zealand and Ms. Christina Tuitubou of the Secretariat of the Pacific Community, Fiji, is much appreciated.

Wilco Liebregts
12 May 2004

INTRODUCTION

1.1 Background

In the Maldives, caterpillars of the pest known by its local name of '*Huvani*' feed on the leaves of a wide range of host trees, including *Terminalia* spp. and fruit trees such as breadfruit, citrus, guava, mango, coconut, etc. During outbreaks, many trees become defoliated as a result of sustained feeding by clusters of large numbers of caterpillars. This significantly reduces tree vitality and production levels. Although this in itself results in major environmental problems, much more serious is the impact on the health of many humans who come in close proximity of the caterpillars when they invade homes in search of food and pupation sites. Outbreaks commonly occur during the dry season (November to June) but also have been observed during other months. The incidence of these outbreaks may vary from a few atolls to a whole archipelago, and often last only a few months, but can be sustained for longer periods, depending on the availability of green leaves for food, the extent of environmental circumstances and the impact of any general predators that influence the pest's abundance and life cycle. All larval stages of the caterpillar have large numbers of hairs, which are shed with every mould. These hairs are dispersed by wind and rain, and when they come in contact with human skin they cause severe irritation, which may vary from an experience of considerable discomfort to itchiness and skin rash which can last for prolonged periods. When inhaled the hairs can cause serious breathing problems. Medical assistance is required in serious cases of irritation and allergic reactions, but treatment is aimed only at alleviation of the symptoms and giving some respite to distressed victims. In serious cases when severe allergic reactions occur including breathing problems, hospitalisation of the patient is required. In addition to health and environment related issues, pest outbreaks have forced families to leave their homes, leading to serious social consequences and additional strain on island communities' livelihoods.

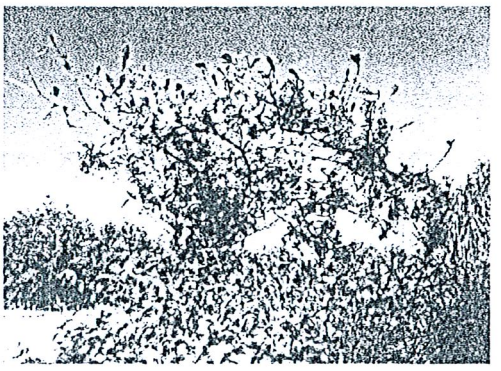


Figure 1. *Severely defoliated* ***T. catappa*** *tree*

Figure 2. *Close up of damage to* ***T. catappa***

Current control measures are based on the extensive use of pesticides, which are applied by fogging and high pressure sprays in inhabited areas during outbreaks. Cocktails of various broad spectrum insecticides are used to achieve maximum impact, but these measures are still inadequate to prevent or control gypsy moth outbreaks and human suffering. Worse, the use of such pesticide cocktails provides an additional and serious risk to people living in these areas, who not only are directly exposed to sprays, but also come in contact with pesticide residues in their environment, and consume contaminated drinking water that is extracted from wells in the islands.

In early 2004, the Ministry of Fisheries, Agriculture and Marine Resources (MFAMR) sought advice on the development of a sustainable, environment friendly control programme of the pest in the Maldives. It was anticipated that this would involve the identification to species of the pest, a review of literature and database search, as well as specialist consultations to determine its region of origin and known distribution, biology and ecology and host range. The assistance would also include a review of control measures applied in the country and elsewhere, and lead to the preparation of a concept proposal for a project to develop an Integrated Pest Management approach for the control of this pest.

The Consultant visited the Maldives from 3 – 21 April 2004. During an earlier visit in February 2004, the Consultant had visited the islands of Gan and Fuah Mulah in the south, and Vilingilli island near Male, to observe the effects of *'Huvani'* outbreaks and collect samples of the pest for incubation in the laboratory, to determine the presence of any natural enemies.

1.2 Identification of the pest

The authoritative identification to species level of a pest is the first step in the development of a management and control strategy for it. Once the identity is known, literature searches can be implemented to identify information on the biology, ecology, host range, geographic distribution range, natural enemies, as well as control methods applied elsewhere. In addition, it will in many instances enable the determination of the region or country of origin of the pest, which is very important if biological control of the pest is considered.

In the Maldives, the moth is better known with its local name of *'Huvani'*. Although it is also known by the English name of *'Gypsy Moth'*, there appears to be no supporting documentation for this name apart from some similarities with *Lymantria dispar* (L.), a species from the temperate zones in the northern hemisphere that officially has been given this common English name. This species is a serious pest of forests in Canada and the USA, and is considered one of the most serious quarantine pests for countries that are free of the pest, such as Australia and New Zealand. Two subspecies of *L. dispar* are known: a European and an Asian subspecies, which both have invaded the temperate zones in North America where they cause extensive damage to forests by defoliation of trees (Humble and Stewart, 1994). The Asian subspecies however is the more aggressive and is credited with a more rapid spread over the continent. There are some similarities in biology and appearance between both subspecies and the species present in the Maldives, but both subspecies have only one generation each year, and their caterpillars and adults are significantly larger.

To determine the identity of the local species, moth specimens emerged from pupae collected in the field and incubated in the laboratory were sent to the Natural History Museum, London, UK in February 2004. They were identified by M. Honey in March 2004 as *Euproctis fraterna* Moore (1883), a species which belongs to the family Lymantriidae of the order Lepidoptera.

Literature from India, where *E. fraterna* appears to be common, refers to the pest with the common English name of *'Plum Hairy Caterpillar'* (Batra and Sinha, 1971; Sandhu et al., 1977; Butani, 1978) and *'Hairy Caterpillar'* (Oblisami et al., 1969). These common names however do not appear to be widely used in other Asian countries where the species is present.

Results from literature searches showed that there are several other species of *Euproctis*, most of which appear to be found in Asia: *E. flexuosa* Veen from Java and the Dutch West Indies (Indonesia); *E. lunata* Walk. from India; *E. pseudoconspersa* from China, Taiwan, and Japan; and *E. scintillans*, which has been renamed to *Porthesia* sp. *E. chrysorrhoea*, the brown tailed moth, is recorded from the UK (D. Palmer, pers.comm. 2004), where it also causes skin irritation to those who come in contact with larvae (Anon.,2004).

1.3 Distribution of *E. fraterna*

The distribution of *E. fraterna* appears limited to south Asia. The pest is common in Pakistan and India, where it is found to inhabit a range of climate zones; it has also been recorded from Bangladesh, Thailand (Kuroko and Lewvanich, 1993), Sri Lanka, and the Maldives. Butani (1978) reports its presence from Burma (Myanmar), but does not provide a reference.

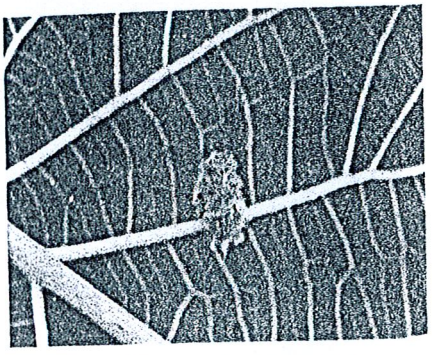


***Figure 3.** Egg mass of E. fraterna*

Euproctis fraterna is most likely an exotic species that would have been accidentally introduced in the Maldives through human intervention. This could have been via egg masses or pupae attached to timber, equipment, construction materials, or seedlings and green leaves, through caterpillars on seedlings or plant cuttings, or adult moths attracted to lights on ships.

The fact that the moth has been given a local Maldivian name -'*Huvani*'- indicates that the pest appears to have been present in the Maldives for quite a number of years. This is confirmed by many adult persons of various ages who recall their experiences with the caterpillars during their school days; many can name years that outbreaks occurred.

In the Maldives, the pest appears to be widespread and common in most atolls. Although the pest may not be continuously present in some islands, perhaps due to e.g. a shortage of host plants, it is very likely that it has reached all atolls.

1.4 Biology and ecology of *E. fraterna*

Bhatnagar and Lakra (1992) describe its biology and life cycle in India as follows:

> *'Hairy caterpillars (*Dasychira mendosa, Euproctis fraterna *(Lepidoptera: Lymantriidae),* Thiacidas postica *(Lepidotera: Noctuidae)) remain gregarious and scrape the leaves and young fruits. The older caterpillars spread in all directions and devour leaves and fruits and sometimes even the tender shoots. They start eating new foliage emerged after pruning and this is continued by overlapping generations. The full-grown larva is reddish brown with dark brown head. The larva pupates on the plant in a yellowish, hairy cocoon from which a yellowish moth with pale transverse lines on the forewings emerges. It then lays flat, circular yellowish eggs in masses on the lower surface of the leaves. The females lay 92-241 eggs, which hatch in 9-14 days. The pre-oviposition, oviposition and post-oviposition periods last 2, 1 and 4 days respectively, and the larval, pre-pupal, pupal and adult stages last 25-56, 2-3, 7-15 and 5-7 days respectively. As many as 6 generations each of 44-84 days duration have been observed in a year.'*

Butani (1978) adds that the larvae are 35-40 mm long, and have tussocks of hair on the entire body. He also mentions that the egg, larval and pupal periods are 1, 6 and 8 weeks during summer, with three generations per year. In Sri Lanka, the caterpillars are more common on

cinnamon from August to December, when the plant produces flushes of new growth and damage can be extensive. The duration of the developmental stages are: 4-9 days for eggs, a total of 13-29 days for 6 instars during larval development, and 9-20 days for pupal development. The length of the life cycle is approximately 6-7 weeks (Rajapakse et al, 1982).

In the Maldives, the biology of *E. fraterna* is very similar, with some minor variations observed during incubation of field collected material. The number of eggs in a single mass shows a greater variation in both minimum and maximum numbers, and their development time is appears to be several days shorter at an estimated 6-7 days, which is due possibly to a higher average temperature. Eggs are deposited in several layers on the underside of leaves of host plants, and after completing egg laying, the female covers the mass with scales ('hairs') from its body, so that no eggs are visible.

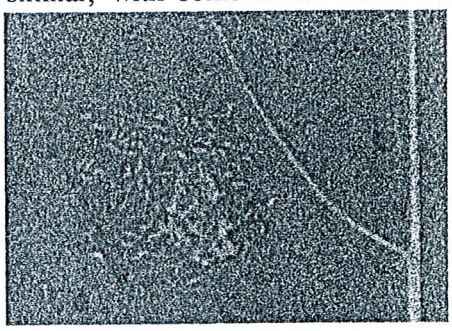


Figure 4. *Newly hatched egg mass*

After some 6-7 days the eggs hatch into larvae, which commence feeding outwards from the egg mass in a single cluster. When they grow larger they start feeding individually, although several caterpillars can often be found feeding on the same shoot. Adult caterpillars can reach some 2–2½ cm, and migrate from the areas where they feed to sheltered spaces for pupation.

Figure 5. *Cluster of young caterpillars*

Sandhu et al. (1977) observed that caterpillars ascended the trees at dusk to feed individually on leaves at night, and before noon descended to the stem portion where they formed dense aggregations of some 225 individuals per 100 sq cm. This gregarious behaviour lasted up to 11 am, and was earlier at higher temperatures (40-47 degrees Centigrade). In Sri Lanka however, Rajapakse et al. (1982) observed gregarious feeding of fully-grown larvae on cinnamon.

Chand et al. (1998) found in Tamil Nadu, India, that caterpillars consumed a significantly higher proportion of mature leaves of *Lannea coromandelica* (Houtt.) than senescent or young leaves, which they related to a preference for a low water-nitrogen index. There, the larval development included five larval stages, with a duration of 30.1 and 35.6 days for respectively males and females. There was no significant difference between the sexes for pupal development (24.5-25.2 days) and adult longevity (5-6 days), but male development at 60 days overall was shorter to that for females of 67.3 days.

During outbreaks, large masses of caterpillars have been observed searching for pupation sites: crevasses and cracks in the bark, but also underneath the overhang of roofs, and materials and equipment stored in the vicinity of the feeding sites. Once a suitable site for pupation has been found, the larva spins a cocoon in which it pupates.

1.5 Host range of *E. fraterna*

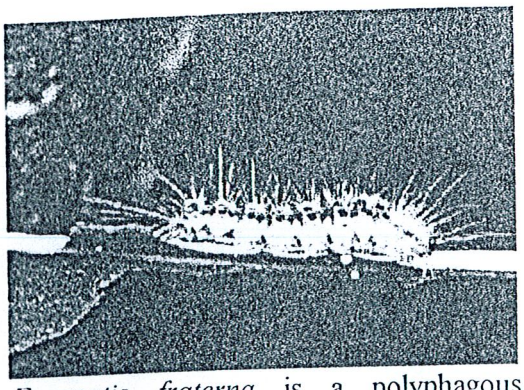


Figure 6. Large caterpillar

Figure 7. Webbings spun by caterpillars before pupation

Euproctis fraterna is a polyphagous species, attacking a large range of plant species in its area of distribution, including banana (Viswanath and Gowda, 1975); cinnamon (Rajapakse and Kulasekera, 1982); citrus and guava (Ram and Pathak, 1987); falsa (Butani, 1978); castor, cotton, pomegranate, rose, pigeon pea and pear (Nayar et al. (1976), quoted by Mukherjee et al, 1991); Indian jujube (Bhatnagar et al., 1992); plum (*Prunus communis*) (Sandhu et al., 1977); *Ricinus communis* (Hossain et al., 1995); sunflower (Arya et al., 1995); sesame (Abraham et al, 1973); *Aleurites fordii, A. montana, Mangifera indica, Ougeinia dalbergioides, Shorea robusta, Tectona grandis, Terminalia myriocarpa, T. tomentosa, Trewia nudiflora, Zizyphus mauritiania* (Beeson, 1941 and Mathur and Singh, 1961, as quoted by Venkatesha et al, 1992); *Paulownia fortunei* (Kumar and Ahmad, 2000). In the Maldives however its host range is more restricted (Table 1).

Table 1. Host range of *E. fraterna* in the Maldives

Scientific name	*Family*	*Common name*	*Reference*
Terminalia catappa	Cambretaceae	Country almond	This report
Guettarda speciosa	Rubiaceae		This report
Pterocarpus indicus	Fabaceae/ Papilionaceae	Burmese rosewood	This report
Psidium guajava	Myrtaceae	Guava	This report
Pemphis acidula	Lythraceae	Ironwood	This report
Calophyllum inophyllum	Guttifer	Alexander laurelwood tree	This report
Cocos nucifera	Aracaceae	Coconut	G. Watson et al, 1995.
Zizyphus mauritania	Rhamnaceae	Indian jujube; Ber; Stone apple	This report
Syzygium cumini	Myrtaceae	Jambolan; Java plum	This report
Artocarpus altilis	Moraceae	Breadfruit	This report
Citrus spp.		Citrus	A. Shafeeq, I. Rasheed, Pers comm. 2004
Mangifera indica		Mango	A. Shafeeq, I. Rasheed, Pers comm. 2004

Alocasia sp.(?), *Colocasia* sp.(?)		Taro	A. Shafeeq, I. Rasheed, Pers comm. 2004
Musa spp.	Musaceae	Banana	A. Shafeeq, I. Rasheed, Pers comm. 2004
Undetermined weeds and grasses			A. Shafeeq, I. Rasheed, Pers comm. 2004

Determining the life cycle of *E. fraterna* in the Maldives is important to provide data that will help developing sustainable control measures of the pest. **Further studies are therefore required to more accurately determine the duration of the life cycle of the pest in the Maldives.**

1.6 Outbreaks of the moth

From time to time, but reportedly with an increasing frequency, *E. fraterna* populations reach outbreak levels in the Maldives. The outbreaks do not appear to be widespread and but occur on only a few islands at a time. In 2003, outbreaks were recorded from the following islands and atolls:

Table 2. Reported outbreaks of *E. fraterna* in 2003

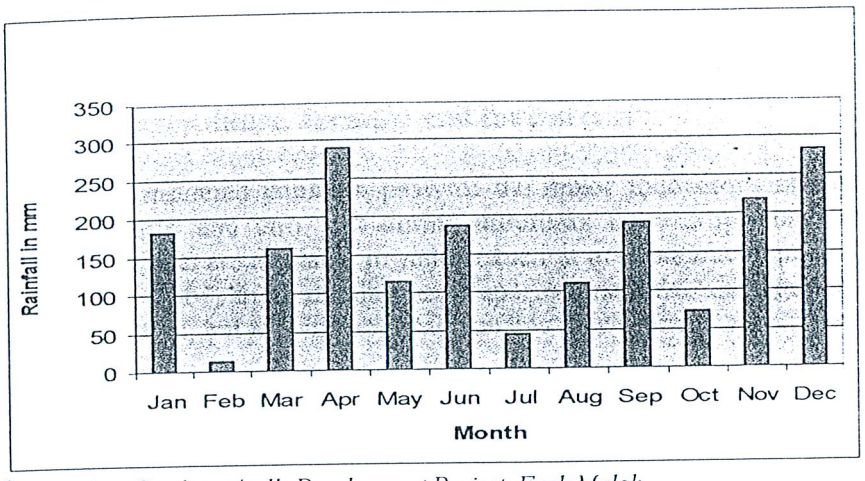
Atoll	*Island(s)*	*Hostplants*
Haa Alifu Atoll	Uligamu; Molhadhoo	*Terminalia catappa* (Cambretaceae)
Baa Atoll	Goidhoo; Kudarikilu; Eidydafushi	*T. catappa* (Cambretaceae), stone apple
Lhaviyani Atoll	Naifaru	*Psidium guajava* (guava)
Kaafu Atoll	Guraidhoo	Wide range of hosts
North Ari Atoll	Rashdoo	*T. catappa*, wax apple
South Ari Atoll	Hanyaameedhoo; Mahibadhoo	*T. catappa*, wax apple, stone apple
Vaavu Atoll	Fulidhoo; Felidhoo	*T. catappa*, wax apple, stone apple
Meemu Atoll	Mulaku; Mulee	*T. catappa*, wax apple, stone apple, *Canophyllum*
Thaa Atoll	Kandhoodhoo	*T. catappa*, wax apple, stone apple, *Canophyllum*
Gaafu-Alifu Atoll	Maamendhoo; Villingili	*Terminalia*, and other vegetation
Fuahmulaku Atoll	Fuahmulaku	Most plants
Addu Atoll	Gan; 2 uninhabited islands near Hithadhoo	*Terminalia*, Ironwood (*Pemphis acidula*)

(Source: Dept. of Agriculture, MFAMR)

The causes of such outbreaks are not fully understood. Temperature and humidity do not vary significantly throughout the year. Rainfall, or rather the lack of it, may be a contributing factor, but an average annual rainfall of some 2000 mm provides reason to doubt this as the single most important factor.

In Fuah Mulah in the southern Maldives, rainfall is higher than in the northern and central regions of the country with an annual average 2273 mm during the period 1985 – 1997.

Figure 8. Monthly Rainfall in mm at Fuah Mulah Atoll, 2003*.



*: *Data from Southern Atolls Development Project, Fuah Mulah.*

During that year, several prolonged periods without rainfall occurred (Table 3), with the longest period of 49 days occurring from 9 June to 6 August when only 45 mm rain fell in one week (13-19 July).

Table 3. Periods and duration of droughts in 2003

Start	*End*	*No. days*		*Comments*
30 January	20 February	21	45	13 mm rain on 20 February
21 February	17 March	24		
9 June	13 July	33	49	45 mm rain between 13-19 July
20 July	6 August	16		
14 August	5 September	(22)		6.5 mm rain during this period
5 October	31 October	26		
18 November	3 December	15		

1.7 Environmental impact

During such outbreaks, the density of caterpillars builds up rapidly, and results in the defoliation of whole trees and even groups of trees. The damage appears to most dramatic on *Terminalia catappa*, of which species many trees were seen completely defoliated during a visit to Fuvah Mulah atoll in February 2004. Whilst the growth and health of the trees would be severely impacted by these outbreaks, the trees are able to survive such impact: fresh regrowth was seen on the trees. Such severe defoliation however is likely to have a serious impact on the population of *E. fraterna*, since the depletion of the food source will increase mortality rates of the caterpillars, and provides less suitable sites for female moth to deposit their eggs. This would then cause populations of caterpillars crash, resulting in a significant reduction in the number of adults. The number of eggs deposited will decline, and the young larvae that emerge will face serious food shortages, further increasing mortality rates. Hence, the life cycle and survival appears to be very much dependent on the availability and abundance of suitable food sources. This hypothesis is supported by Chand et al. (1998), who found that in Tamil Nadu, India, the larval host plant *L. coromandelica* sheds its leaves

in June every year, with new leaves developing immediately after the first monsoons in June and July. During the period September – November when leaves mature, infestation by *E. fraterna* takes place.

1.8 Effects on agriculture, forestry and food security

Caterpillars are not considered common pests of the major food crops including banana, breadfruit, mango, citrus and taro, but during outbreaks these crops may incur serious damage. Although no data are available in yield reduction or economic impact, Shafeeq and Naseem (Pers comm., 2004) in an unpublished paper estimate that damage could result in about 60% yield reduction, but provide no details on how this estimate was arrived at.

1.9 Impact on human health

Of serious concern is the impact of *E. fraterna* on human health. The hairy caterpillars are the most problematic: their hairs contain histamine, which break off easily and when coming in contact with human skin produce an allergic reaction that causes a highly irritating skin rash. The hairs are shed by large caterpillar when it commences pupation and incorporated in the cocoon in which the pupal development takes place. Adult moths also have hairs that can cause skin irritation (dermatitis). When hairs are inhaled they can cause respiratory problems that may require hospitalization and treatment.

Worse, the behaviour of the caterpillars involves the search for sheltered sites where it can pupate. Under normal conditions, when pest population levels are low, the trees and nearby surroundings provide sufficient sites for this, such as splits in branches or underneath the bark. When population levels are high however the number of sites is insufficient to accommodate all caterpillars, and they migrate in masses in search for suitable sites. Nearby houses provide a large number of sheltered places which attract the caterpillars. With such house invasions difficult to control, the exposure to residents is so high that many are forced to leave their houses until the outbreak subsides.

Statistics from the Ministry of Health on the incidence of dermatitis in Male' are not sufficiently specific to identify those cases resulting from contact with 'Gypsy Moth'. However, data from the Medical Centre at Fuah Mulah show that 140 patients with dermatitis sought medical consultation there from July and November 2003 (Table 4). This is the period leading up to and including the outbreak of the moth there. It is worth noting that no cases were reported during the first six months of the year before the outbreak. However, the Haveeru newspaper of 8 December 2003 reports that in September already people were forced to leave their residences due to invasion by the caterpillars.

Table 4. Cases of dermatitis reported from Ganviyani Fuah Mulah in 2003

Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
0	0	0	0	0	0	9	23	34	9	65	148*	288*

(Source: Fuah Mulah Health Authorities)
**: Calculated from two data sets provided by Fuah Mulah hospital*

During the height of the outbreak (1 October to 31 December 2003), 222 cases of dermatitis were reported in Fuah Mulah (Table 5). It is however very likely that the number of people affected by the pest is considerably higher, as many simply do not visit the hospital for consultation with physicians. Although there was a significant difference between affected females and males over 12 years of age, resp. 65% and 35% (Table 5), this may be due to the fact that females more commonly are occupied with domestic duties in and around the residence. There was no significant difference between the number of affected boys and girls up to 12 years of age.

Table 5. Categories of patients reporting with dermatitis at Fuah Mulah hospital, October-December 2003 (Source: Fuah Mulah Health Authorities)

Age Group	*Sex*	*Number of cases*	*Percentage of total*	*Total*
< 12 years	Male	47	53.4 %	88
< 12 years	Female	41	46.6 %	
> 12 years	Male	47	35.1 %	134
> 12 years	Female	87	64.9 %	
All ages	Male	94	42.3 %	222
	Female	128	57.7%	

****

CONTROL MEASURES

Control measures in the Maldives are applied *curatively*, to reduce caterpillar and moth abundance once the pest has reached outbreak levels. In general, most control methods appear to have had an unsatisfactory result in that after their application pest populations did not appear to be sufficiently reduced, although some had little or moderate effect. The control measures applied include chemical and mechanical (physical) control.

2.1 Chemical control

Of all developmental stages of the pest the caterpillar is the easiest target as it is the most susceptible to insecticides. A range of common insecticides can be used, with the synthetic pyrethroids cypermethrin, decamethrin, fluvalinate and fenvalerate the most effective (Bhatnagar and Lakra, 1992).

Insecticides used in Male' and Fuah Mulah to control outbreaks of the 'Gypsy moth' include: Nimbecidine (neem oil), Cypermethrin, Chlorpyrifos, Carbofuran, and Malathion. With the exception of the first two, the toxicity to humans and persistence in the environment of the Clorpyrifos and especially Carbofuran is high to very high, and their use should be avoided. There is anecdotal information that a resort island attempted to control an outbreak of the moth by spraying 1000 litres of Malathion in pure, liquid form. Whilst insecticides are known

to have many undesirable effects, the application of the latter would have been very damaging to the environment.

In Male', the responsibility of controlling caterpillars of *E. fraterna* is with the Male Municipality, which takes advice from MFAMR and commonly treats infested trees with sprays of soapy water following requests from residents, and prunes infested trees to reduce the available food source for caterpillars. On municipal areas (eg. cemeteries) however, where there is less risk of direct contact with humans, infested plants are not only treated with this soap solution, but the highly toxic insecticide and nematicide Carbofuran is applied to the nearby soil to kill any caterpillars that survive and feed on nearby grasses, weeds and shrubs. Spray equipment is borrowed from the Department of Public Health, which uses it for mosquito control. Spraying takes place in the early hours of the morning at around 5 am to reduce impact on residents. The cost of the control programme for Male' and Villingili wards is estimated at MRf 100,000 per annum (A. Shafeeq, M. Naseem and Shaugee, pers. comm. 2004).

During the pest outbreak that occurred from October 2003 to January 2004 in Fuah Mulah, two phases of pesticide applications took place: a first phase from 10 November to 4 December, and a second phase from 26 December 2003 to 30 January 2004. Whereas the first phase concentrated on pesticide application to host trees, the second phase targeted the prevention of invasion, and killing caterpillars in and near houses that had already been invaded. In total 1062 houses received pesticide treatment. The Haveeru newspaper however reports in its issue of 8 December 2003 that the people were dissatisfied that the pesticides did not appear to reach their target, and mentions attempts by the local population to kill moths with brooms.

The first phase of the spraying programme was contracted out to private contractors at considerable cost. The second phase was implemented by the atoll office and the island office with help from the public. Equipment, pesticides and technical assistance were provided by the Ministry of Fisheries, Agriculture and Marine Resources (MFAMR).

2.2 Light trapping

On advice from MFAMR, light trapping was used to catch moths during the outbreak in November and December 2003 at Fuah Mulah atoll in between both phases of pesticide application for a period of three weeks (I. Rasheed, pers comm. 2004). Light traps consisted of a 'energy saver' light bulb (approx. 15-20 W) suspended from a large tree (most commonly *Terminalia*) between 0.5 – 2 m. above ground level. A partial, non-transparent shade was affixed over the light; a bucket filled with soapy water was placed approximately 30-50 cm below the trap. Moths were strongly attracted to the light and, when coming in contact with it, dropped into the bucket, where they drowned. Trapping was continued for three weeks on a daily basis with 50 traps and, although no accurate records were kept, daily captures of 400-500 were not uncommon at the start. Moth numbers dropped significantly over the three weeks, indicating an end of the outbreak.

2.3 Biological control

Several species of natural enemies of *E. fraterna* have been recorded, mostly from India and Pakistan (Table 6).

Table 6: Parasitoids recorded from *E. fraterna* worldwide

Species	*Order and Family*	*Country*	*Stage attacked*	*Reference*
Apanteles sp.	Hymenoptera: Braconidae	India	larva	Thompson, W.R., 1945
Apanteles sp.	Hymenoptera: Braconidae	Pakistan	Larva	M. Irshad, Pers comm. 2004
Apanteles prodiniae Viereck	Hymenoptera: Braconidae	India	Larva	Venkatesha et al., (1992)
Apanteles taprobanae	Hymenoptera: Braconidae	India	Larva	Bhatnagar and Lakra (1992)
Brachymeria sp.	Hymenoptera: Chalcididae			
Carcelia amphion R.D.		Pakistan		M. Irshad, Pers comm. 2004
Carcelia modicella Wulp.		Pakistan		M. Irshad, Pers comm. 2004
Charops obtusus	Hymenoptera: Ichneumonidae			
Disophrys sp.	Hymenoptera: Braconidae	India		Thompson, W.R., 1945
Enicospilus sp.	Hymenoptera: Ichneumonidae	India		Thompson, W.R., 1945
Enicospilus merdarius Grav.	Hymenoptera: Ichneumonidae	India		Thompson, W.R., 1945
Euagathis semiflavus Szepl.		Pakistan		M. Irshad, Pers comm. 2004
Euagathis sp.		Pakistan		M. Irshad, Pers comm. 2004
Euplectrus ceylonensis How.	Hymenoptera: Eulophidae	Sri Lanka (Ceylon)	Larva	Thompson, W.R., 1945
Euplectrus sp.	Hymenoptera: Eulophidae	India	Larva	Venkatesha et al. 1992
Goryphus sp.	Hymenoptera: Ichneumonidae			
Meteorus sp.	Hymenoptera: Braconidae	Pakistan		M. Irshad, Pers comm. 2004
Mesocomys orientalis Ferriere	Hymenoptera: Eupelmidae	Bangladesh	Eggs	Ahmed et al., 1995
Sturmia sp.	Diptera: Tachinidae	Pakistan	Larva	M. Irshad, Pers comm. 2004

n the Maldives, initial surveys for parasitoids of eggs, larvae and pupae have shown that at east three species of parasitoids are present, with the presence of a possible fourth (possibly a *Trichogramma* sp.) awaiting confirmation following the incubation of egg masses collected on 19 April 2004 (Table 7).

Table 7. Natural enemies of *E. fraterna* in the Maldives

Species	*Family and Order*	*Localities*	*Stage attacked*
Telenomus (Aholcus) sp.[a]	Hymenoptera: Scelionidae	Villingili, Male' Atoll Fuah Mulah	Egg
Unidentified egg parasitoid	Hymenoptera: (Trichogrammatidae?)	Villingili	Egg
Unidentified pupal parasitoid	Hymenoptera:	Villingili, Male' Atoll	Pupa
Unidentified pupal parasitoid	Hymenoptera: Braconidae(?)	Villingili, Male' Atoll	(Larva?)/Pupa(?)

[a] *Identified by A. Polaszek, Natural History Museum, UK, March 2004*

Several egg masses of *E. fraterna* were collected from *T. catappa* leaves on Villingili in February and April 2004 for incubation in the laboratory to determine egg mass size and mortality caused by parasitoids. On 7 April 2004 three egg masses (resp. 61, 178 and 242 eggs) were collected and incubated. Six days after collection all (100%) eggs produced larvae. No parasitoids were found. A further collection of 17 egg masses from *T. catappa* took place at Villingili on 19 April; results have yet to be determined.

Shafeeq and Ali (pers comm., 2004) mention achieving control of *E. fraterna* in Maafahi Island in 1997 following the introduction and release of the egg parasitoid *Trichogramma* sp. The introduction appears to have taken place by means of 'inundative' releases, which involved the release of many tens of thousands of parasitoids into the environment. Many species of *Trichogramma* parasitoids are reared commercially and can be purchased at reasonable costs from companies and institutions overseas, and the species used for this purpose was sourced similarly. The parasitoid gave a quick control of the pest, and no additional control efforts were needed: no outbreaks have been reported from the island since.

****

CONCLUSIONS

A substantial amount of work on the control of *'Huvani'* had already been done by MFAMR staff, in particular Mr. Ismail Rashid. However, the first step in the development of control measures for pest control - the identification of the pest to species - was unfortunately overlooked, and it was only in February 2004 that specimens were sent for authoritative identification.

Possibly because of similarities the pest was thought to be closely associated with the 'real' Gypsy Moth *L. dispar*. Hence, literature on this pest was collected and several of the methods used for its control in Canada and the USA were selected for application in the Maldives. However, although these control methods appear to have been tested individually for their impact on controlling the pest during outbreaks, the complementary action of a combination – or rather integration - of approaches was not adequately tested. An exception here is the switching between chemical control of caterpillars and light trapping of moths, and back again to chemical control during the outbreak in Fuah Mulah in late 2003.

The control measures applied by MFAMR are applied when the pest has reached outbreak levels. This ***curative*** approach aims to ***reduce pest populations during outbreaks*** i.e. when the damage is already occurring. It is the more commonly used approach in the Maldives, and is intended to yield immediate results on the short term. It must however be applied every time an outbreak occurs: it is costly, and cannot prevent the defoliation of trees, nor the impact on human health.

The key to the development of a sustainable and effective control strategy for *E. fraterna* is to target a ***preventive*** approach which aims to ***prevent outbreaks from occurring***. This approach is based on acquiring information that will lead to **an understanding as to why and how outbreaks occur**, and relies on information on the pest's biology, ecology, and its interactions with its plant hosts, natural enemies and the weather. It is an integrated approach, aimed at establishing **IPM – Integrated Pest Management** - the concept of which is based on an optimum use of non-chemical control methods to prevent population levels of the pest from increasing to economically damaging levels, with pesticide applications only then used when deemed necessary.

The development of an IPM approach requires detailed information much of which is not yet available in the Maldives. Therefore, some field studies are required that involve regular pest monitoring for a period of time (for at least one year) to gain an understanding of the environmental, biological and ecological factors that influence the population dynamics of the pest and contribute or lead to the development of outbreaks. This includes an assessment of the presence and effectiveness of natural enemies in contributing to pest mortality over time. It will also include the testing of single or a combination of control measures, some of which may yield useful results, some however may not.

Proposed approaches for research and development of Integrated Pest Management of *E. fraterna* in the Maldives

proposed project approach for the development of an IPM programme for control of *E. aterna* is given in Appendix 2. Whilst this is under consideration by MFAMR however, itial field studies should be commenced already to give an early start to data collection. The udies described below can be implemented with simple means, however they require a keen ommitment.

A. Studies to gain an understanding of the biology, population dynamics and ecology of *E. fraterna*.

1 Studies on population dynamics of E. fraterna pupae and adult moths

opulation densities of selected developmental stages of the pest should be monitored on a egular basis, to provide information on the fluctuations of the pest over time. A suitable tage for monitoring is the **pupal stage**, which can easily be surveyed at the surrounding wall t the Villingili housing compound. Pupae attached to both sides of the wall should be ounted and collected for incubation in the laboratory to determine survival and mortality ates, and identity and impact of at least 2 species of parasitoids that have been found to ttack pupae there. Surveys should be implemented on a 4-weekly or monthly basis, and ontinue for at least a year.

he same island can be used for monitoring of abundance of **adult moths**, which also rovides data on population dynamics. Since the moths are strongly attracted to lights, a few minimum two) light traps should be set up at a site distant from street and home lights to inimise interference. Monitoring should be done at least once every 4 weeks or month, but referably every 2 weeks.

2 Assessment of size of egg masses and mortality factors

n some Lepidoptera the size of the egg masses deposited is related to the fertility and fitness f the female. Monitoring egg mass size over time therefore can provide indications on the vailability and suitability of nutrients, and the fitness and health of the larvae and adult opulations. At the same time, incubation of egg masses will yield valuable data on the urvival rates and numbers of larvae, and egg mortality caused by parasitoids and predators. ollection of egg masses should take place once every four weeks or month; during each ampling attempts should be made to collect a minimum of 10 masses for incubation.

3 Observations on ecology and growth patterns of major host plants

he major host plant of *E. fraterna* in the Maldives is *T. catappa*. This tree produces at arious times during the year 'flushes' of new growth, which provides a highly suitable food or the caterpillars. At other times though the tree sheds most of its foliage, leaving little ood for the pest. It is important to make general observations on these growth patterns, as hey are likely to play an important role in the ecology of the pest. Such observations should e in the form of 'field notes', and made during the sampling of activities 1 and 2.

B. Studies to test measures for control of *E. fraterna*

In addition to the studies mentioned before, the following control measures should each be tested for use in the Maldives. It is recognized however that these could only produce good results when implemented during outbreaks when larger populations of *E. fraterna* are available for testing. They are considered complimentary, so that the use of one method will not reduce the need for using any of the other methods. It should be considered however that in some situations the use of a single method or a combination of a few may be the more preferred one.

1 Light trapping

The use of light traps proved very efficient during the outbreak at Fuah Mulah in late 2003. Many adult moths were attracted and subsequently killed with light traps during a period of 2 weeks. The use of these to determine the build up of *E. fraterna* populations will allow many more traps to be used to trap many adults that would otherwise be allowed to deposit eggs. Although the use of this method by itself may not help prevent outbreaks, its combination with other control methods appears promising and should be considered in developing an IPM strategy.

Advantages

- Proven to be effective in trapping moths
- Environment-friendly
- Relatively easy to apply and use
- Well suited for use in urban areas and near houses

Disadvantages

- The construction and operation of light traps will incur some costs for materials and electricity
- Requires daily monitoring, and operation
- Applicable only in urban areas or near houses

2 Burlap method

The Burlap method is used to control larvae of the Gypsy Moth, *L. dispar*, on a smaller scale. In the morning, caterpillars of this species migrate down the trunk and major branches of the tree they inhabit to hide in crevasses during day time. In the evening the direction of the migration reverses as they move back to the foliage of the tree for feeding, to return again down the trunk. Presumably this migration is undertaken to avoid parasites and predators.

A system whereby a burlap – a piece of cloth of some 50 cm wide and at least as long as the circumference of the tree trunk is tied along the middle of the cloth around the infested tree at waist height. The upper half of the cloth is allowed to hang down over the other (lower), creating a shelter for the caterpillars. When moving down the trunk in the morning the caterpillars will move under the burlap where they remain until evening. The caterpillars are collected from underneath the burlap and killed.

Advantages

- Environment-friendly approach to destroy caterpillars
- Low-cost
- Easy to apply and use
- Well suited for use on trees in urban areas and near houses

Disadvantages

- Requires testing for effectiveness
- Not applicable to large numbers of trees or plantation forests

is method requires testing before it should be promoted to people.

3 Impregnation of exterior house walls with a semi-persistent pesticide

vasion by large masses of caterpillars may occur during outbreaks. When caterpillar mbers are high competition for pupation sites on or near the host plants is high, and terpillars move out in search for alternative sites, such as houses and sheds in the vicinity here many such sites are in abundance. The mass migration of caterpillars requires them mb onto outside walls of houses to seek shelter underneath roofs and awnings. It is ggested that semi-persistent contact insecticides are applied underneath the roofs on the tside of the walls. Any caterpillars moving over this surface would come in contact with e poison and die. This hypothesis will require testing, including the overall effectiveness of e method, as well as to determine the most effective type of insecticide, the width of the ea requiring treatment, and the minimum interval between successive sprays.

eally, only the areas underneath the roof should be treated, to avoid exposure to humans, in rticularly children that play around the house.

Advantages

- If found to be effective, it would reduce house invasions by caterpillars
- Applications may only be necessary once or twice during outbreaks
- Applications can be organized and applied by island or atoll councils

Disadvantages

- Requires testing
- Pesticide application equipment and manpower needed
- Involves application of semi-persistent pesticides around houses, and poses a risk of exposure to humans

4 Application of Bacillus thuringiensis *var.* Kurstaki *(BTK)*

cillus thuringiensis var. *Kurstaki* (BTK) is a biological pesticide, which is derived from an tomopathogenic bacteria, and is used for control of *L. dispar* in Canada (Anon. 2004). This ecticide specifically targets caterpillars and does not affect adult moths, nor its natural emies. This is unlike chemical pesticides which have been applied in the Maldives for

ntrol of *E. fraterna* that also kill non-target organisms and natural enemies of the pest. TK can be applied in a way similar to the chemical pesticides, but unlike those, is harmless humans.

Advantages

- Does not affect non-target organisms except other species of caterpillars feeding on the tree
- Is harmless to humans, and can therefore be used safely in urban areas
- Can be applied with similar equipment used for application of chemical pesticides
- Can be applied to large areas to achieve extensive control

Disadvantages

- Its effectiveness in controlling E. fraterna caterpillars requires further testing
- Mortality occurs is not immediate and may take several days before the effects become visible
- Not very suitable for application to a few trees
- Shelf life is relatively short, unlike chemical pesticides

5 Strengthening the complex of biological control agents present in the Maldives

urrently three parasitoids have been reared from *E. fraterna*: the solitary parasitoid *elenomus* (*Aholcus*) sp., which attacks egg masses of the moth; an unidentified species of arasitoid which attacks pupae, and an unidentified gregarious larval parasitoid. A single ndividual of a fourth species of parasitoid (possibly *Trichogramma* sp.) was found on an egg ass at Villingili on 19 April, but its confirmation as a parasitoid of *E. fraterna* can only be onfirmed after results of incubation of the mass are known. Although the first three species entioned appear to be quite common, the mortality caused by each is not known, and should e the subject of further studies.

he importation of one or more species could strengthen the parasitoid complex of *E. raterna* and lower the abundance of eggs, larvae and moths. A number of other species of arasitoids exist that attack the pest in India and Pakistan, but their impact on pest opulations is not clear. Surveys in these countries for parasitoids, followed by their dentification and testing of their suitability for introduction into Maldives should be mplemented over a period – normally several months at least, but mostly over a prolonged eriod - to determine the most suitable parasitoid or parasitoids.

Advantages

- increased stability of parasitoid-pest complex, resulting in lower pest numbers and/or a reduction in the number of outbreaks
- Environment-friendly
- Long term benefits provide for reduced costs over the long term

Disadvantages

- Surveys are quite intensive and costly

- Support from country governments required for surveys and export of natural enemies
- Successful outcomes of surveys and subsequent importation not fully certain
- Highly qualified expertise required
- Immediate results can not be expected; must be viewed on the longer term.

A cautionary note on the use of pesticide sprays

The application of chemical pesticides to host plants should be avoided wherever possible, in particular those with a broad spectrum action. Most pesticides are hazardous to humans, and many do not only kill the target pest, but also their natural enemies and other insects that are not harmful. This influence may be so drastic, that outbreaks of the moth could be prolonged simply because the natural enemies are not given the opportunity to develop and contribute to egg, larval and pupal mortality. It is acknowledged however that chemical pesticides provide for a quick and visible effect on the caterpillars and may, in some cases, be the only option to reduce pest abundance.

REFERENCES

Ahmed, K.N., Husain, M.M., and Pramanik, S.H.A. 1995. Morphology of the egg parasite, *Mesocomys orientalis* Ferriere (Hymenoptera: Eupelmidae). Journal of the Asiatic Society of Bangladesh Science. 21(2): 259-261.

Anon.(2004). Brown tail moth. Havant Borough, Hampshire, UK. http://www.havant.gov.uk/havant-732&menupage=8

Anon. (2001). Gypsy moth guide for homeowners, cottage growers, campers and movers in New Brunswick. Forest Pest Management, New Brunswick – Natural Resources and Energy. 9p.

Anon. (2004). Longan and lychee fruit from the People's Republic of China and Thailand – Final Import Risk Analysis Report, Part B. Department of Agriculture, Fisheries and Forestry, Australian Government. 176 pp.
www.affa.gov.au/corporate_docs/publications/pdf/market_access/biosecurity/plant/II_finalb.pdf

Batra, R.C. and Sinha, M.K. 1971. A fungal parasite of plum hairy caterpillar, *Euproctis fraterna* Moore (Lepidoptera:Lymantriidae). Labdev. Journal of Science and Technology, 9B (3-4):228-229.

Beeson, C.F.C. 1941. The ecology and control of the forest insects of India and the neighbouring countries. Vasant press, Dehra Dunn: 1007 pp.

Bhatnagar, P., and Lakra, R.K. 1992. Biology and control of hairy caterpillar, *Euproctis fraterna* Moore (Lepidoptera: Lymantriidae) on jujube (*Zizyphus mauritiana* Lamk.). Bioecology and control of insect pests: Proc. of the National Symposium on Growth, Development & Control Technology of Insect Pests. Uttar Pradesh Zoological Society, Muzaffarnagar, India. Pp. 150-155.

Butani, D.K. 1978. Insect pests of falsa (*Grewia asiatica* Mast.) in India and their control. Fruits (France). 33(2): 121-124.

Chand, D.S., Sanjayan, K.P., and Muralirangan, M.C. 1998. Implications of the spatial distribution pattern of the plant community on the insect diversity in a scrub jungle ecosystem. Proc. of the National Seminar on Environmental Biology, April 3-5, 1998. Ed. Aditya, A.K. and Haldar, P. Daya Publishing House, Delhi. 236-249.

Humble, L., and Stewart, A.J. 1994. Gypsy Moth. Forest Pest Leaflet. Canadian Forest Service, Victoria, B.C. Website: www.pfc.forestry.ca

Kumar, M., and Ahmad, M. 2000. Record of Lymantriid species defoliating *Paulownia fortunei* in India. Indian Forester, 126:1319-1325.

Kuroko, H. and Lewvanich, A. 1993. Lepidopterous pests of tropical fruit trees in Thailand (with Thai text). Tokyo, Japan: Japan International Cooperation Agency, 132 pp.

lathur, R.N., and Singh, B. 1961. Details on list of insect pests of forest plants in India and le adjacent countries. Indian For. Bull. Ent., 171(9): 1-116.

lukherjee, S.N., Ghumare, S.S., and Sharma, R.N. 1991. Rearing of *Euproctis fraterna* loore (Lymantriidae: Lepidoptera) on artificial diet. Entomon 16(1): 69-71.

ayar, K.K., Ananthakrishnan, T.N., and David, B.V. 1976. General and applied ntomology. Tata McGraw-Hill Publishing Company Ltd., New Delhi, 589 pp.

blisami, G., Ramamoorthi, K. and Rangaswami, G. 1969. Studies on the pathology of some rop pests of South India. Mysore Journal of Agricultural Science. 3(1): 86-98.

ajapakse, R.H.S., and Kulasekera, V.K. 1982. Some observations on the insect pests of nnamon in Sri Lanka. Entomon 7(2):221-223.

am, S. and Pathak, K.A. 1987. Occurrence and distribution of pest complex of some tropical nd temperate fruits in Manipur. Bull. Ent. 28(1): 12-18.

andhu, G.S., Sohi, A.S. and Khangura, J.S. 1977. Spot treatment of high-volume sprays at ow-volume rates using ultra-low-doses of different insecticides for the control of plum hairy aterpillar. Pesticides (India). Vol. 11(12), p. 43-44.

hompson, W.R. 1945. A Catalogue of the parasites and predators of insect pests. Section 1: arasite Host Catalogue – Part 6: Parasites of the Lepidoptera (CI-F). Imperial Agricultural ureaux, Institute of Entomology, Parasite Service. Belleville, Ont. Canada, The Imperial arasite Service.

enkatesha, Gopinath, K., and Chandramohan, K. 1992. New host record and some arasitoids of *Euproctis fraterna* (Moore) (Lepidoptera:Lymantriidae), a pest of forest trees n India. Indian Journal of Forestry. Vol. 15(4): 358.

Vatson, G.W., Ooi, PAC and Girling, D.J. 1995. Insects on plants in the Maldives and their anagement. International Institute of Biological Control, Silwood Park, Ascot, Berks SL5 TA, UK. 124 pp.

APPENDIX 1

TERMS OF REFERENCE

Project Outline

The Gypsy Moth: a serious pest of public health and environmental concern in the Maldives

Pre-feasibility study for the development of a sustainable, environment-friendly control programme

The gypsy moth caterpillars feed on the leaves of a wide range of host trees, including *Terminalia* spp., *Cordia subcordata*, and fruit trees such as breadfruit, citrus, guava, mango, coconut, etc. During outbreaks, many **trees become defoliated** by sustained feeding by large numbers of caterpillars that feed in clusters, resulting in significantly reduced tree vitality and for fruit trees, production levels. Although this in itself results in major environmental problems, much more serious is the impact on the health of many humans who come in close proximity of the caterpillars when they invade homes in search of food and pupation sites. **Outbreaks** commonly occur during the dry season (November to June) but have been observed to also occur during other months; their distribution may vary from a few atolls to the whole archipelago. They often last few months, but can be sustained for longer periods, depending on the availability of green leaves for food, and the extent of environmental circumstances and any general predators that influence the pest's abundance and life cycle.

All larval stages of the caterpillar have large numbers of hairs, which are shed with every mould. These hairs are dispersed by wind and rain, and when they come in contact with human skin they cause **severe irritation**, which may vary from an experience of considerable discomfort to itchiness and skin rash which can last for prolonged periods. When inhaled the hairs can cause serious **breathing difficulties**. Medical assistance is required in serious cases of irritation and allergic reactions, but treatment is aimed only at alleviation of the symptoms and giving some respite to distressed victims. In serious cases when severe allergic reactions occur including breathing problems, hospitalisation of the patient is required. In the Maldives, some .. cases require medical care: some .... are hospitalised each year. In addition to health and environment related issues, pest outbreaks have forced families to leave their homes, leading to serious social consequences and additional strain on island communities' livelihoods.

Control measures are solely based on the extensive use of pesticides, which are applied by fogging and high pressure sprays in inhabited areas during outbreaks. Cocktails of various broad spectrum insecticides are used to achieve maximum impact, but are still **inadequate to prevent or control** gypsy moth outbreaks and human suffering. Worse, the use of such pesticide cocktails provides an additional and serious risk to people living in these areas, who not only are directly exposed to sprays, but also come in contact with **pesticide residues** in their environment, and consume **contaminated drinking water** that is extracted from wells in the islands.

here currently is no technical specialist expertise available in the Maldives to provide advice local authorities on predicting moth outbreaks and development of approaches for suitable ntrol programmes of the Gypsy Moth pest. Hence, the Ministry of Fisheries, Agriculture d Marine Resources (MFAMR) has taken the initiative to contact overseas based stitutions for help with the identification of the pest. This information will help in the velopment of approaches for developing a sustainable, environment friendly control of the st in the Maldives. It is herefore that MAFMR, in collaboration with the Ministry of alth seeks assistance from development assistance agencies for the implementation of a asibility study that will address these issues.

roposed project

he proposed project aims to provide an accurate determination of the Gypsy Moth species, nd its area or region of origin. It further will collect and summarise available information on e biology and ecology of the pest, and identify control methodologies, in particular the otential for biological control options, which are environment-friendly, more sustainable ver the longer term, and do not require expensive and frequent applications of pesticides. It ill develop a proposal for a project to develop such methods, which will be submitted to the evelopment assistance donor community for funding.

ore specifically, the project will be a feasibility study to investigate the Gypsy Moth roblem in the Maldives in detail, and develop a project approach for the development of ustainable, integrated control measures that are appropriate for the Maldives. It will:-

- Identify the Gypsy Moth to species, and determine its country or region of origin;
- Describe the biology and ecology of the pest;
- Determine the host range of the caterpillars;
- Determine the national distribution;
- Determine the impact of recent outbreaks on human health;
- Assess the potential for integrated and biological control measures of the pest;
- Prepare a proposal for a suitable approach for the development of control measures of the Gypsy Moth in the Maldives

APPENDIX 2

Proposal for the development of an Integrated Pest Management programme of '*Huvani*', *Euproctis fraterna* (Lepidoptera: Lymantriidae) in the Maldives

Background

In the Maldives, the caterpillars of *Euproctis fraterna* feed on the leaves of a wide range of host trees, including *Terminalia* spp. and fruit trees such as breadfruit, citrus, guava, mango, coconut, etc. During outbreaks, many trees become defoliated by sustained feeding by large numbers of caterpillars that feed in clusters, resulting in significantly reduced tree vitality and for fruit trees, production levels. Although this in itself results in major environmental problems, much more serious is the impact on the health of many humans who come in close proximity of the caterpillars when they invade homes in search of food and pupation sites. Outbreaks commonly occur during the dry season (November to June) but have been observed to also occur during other months; the outbreaks may vary ranging from a few islands in an atoll, to many islands in several atolls in a region. They often last few months, but can be sustained for longer periods, depending on the availability of green leaves for food, and the extent of environmental circumstances and any general predators that influence the pest's abundance and life cycle.

All larval stages of the caterpillar have a large number of hairs on their body, which are shed with every mould. They are loosely attached, and break of easily, whence they can be dispersed by wind and rain over considerable distance. When the hairs come in contact with human skin they cause severe irritation, which may vary from an experience of considerable discomfort to itchiness and skin rash, which can last for prolonged periods. When inhaled the hairs can cause serious breathing difficulties. Medical assistance is required in serious cases of irritation and allergic reactions, but treatment is aimed only at alleviation of the symptoms and giving some respite to distressed victims. In serious cases when severe allergic reactions occur including breathing problems, hospitalisation of the patient is required. As an illustration of its severity, the island of Fuah Mulah in the southern Maldives reported in 2003 that 222 cases of patients with skin irritation caused by Huvani required medical care; several of the patients were hospitalized. In addition to health and environment related issues, many homes are invaded during outbreaks by large number of caterpillars seeking sites for pupation, which forces families to temporarily leave their homes. This leads to serious social consequences and additional strain on island communities' livelihoods.

Current control measures are solely based on the extensive use of pesticides, which are applied using fogging methods and high pressure sprays. Cocktails of various broad spectrum insecticides are used to achieve maximum impact, but the cost of such spraying programmes restricts their use to reducing pest populations in inhabited areas only during outbreaks. Since they are not applies in farm and forested areas, these areas provide a source for re-infestation as young adult moths disperse over the island. Thus, the pesticide sprays are inadequate to prevent or control gypsy moth outbreaks and human suffering. Worse, the use of such

pesticide cocktails provides an additional and serious health risk to people living in these areas, who not only are directly exposed to sprays, but also come in contact with pesticide residues in their environment, and consume contaminated drinking water that is extracted from wells in the islands.

There currently is no technical specialist expertise available in the Maldives to provide advice to local authorities on the development of moth outbreak prediction systems and development of approaches for suitable control programmes of the Gypsy Moth pest. In response to an initiative from the Ministry of Fisheries, Agriculture and Marine Resources (MFAMR), a specialist in insect population dynamics and Integrated Pest Management visited the Maldives in February and April 2004 to help identify the pest, determine the extent of the pest problem and recommend appropriate activities as an initial step towards development of a pest management system. The specialist recommended the commencement of studies on (1) the population dynamics of the pest, (2) the identity and effectiveness of natural enemies, and (3) pest – host plant interactions. He further recommended that the importation of suitable natural enemies is considered to complement the impact of those already present in the Maldives.

It is in view of these recommendations that MFAMR, in collaboration with the Ministry of Health seeks support from development assistance agencies for the implementation of a project that will enable these studies. The project would also initiate surveys for natural enemies in India, Pakistan and Sri Lanka, in anticipation of selecting suitable species for importation into the country to achieve a sustainable pest management systems for '*Huvani*'.

Proposed project

The project will target to achieve sustainable control the '*Huvani*' pest at two levels:

1 To predict the development of pest outbreaks, and the development of control measures to prevent or reduce them; and

2 To develop a sustainable, Integrated Pest Management approach that uses a variety of complementary measures – biological, physical, chemical and/or mechanical - for maintaining pest populations at low levels

The process of developing control methods aimed at sustainably reducing pest populations and decreasing the risk of or prevention of outbreaks without causing a significant impact on the environment, non-target species or humans, involves a series of phases that address both biological and physical factors. Each phase however is necessary and, whilst some can be implemented simultaneously, the implementation of others will depend on the outcomes of previous ones.

Following the required identification of the pest to species, it is crucial to acquire an understanding of the pest, and its interactions with the immediate environment - its habitat, and the physical and biological factors that influence it. This will require both field and laboratory studies and surveys to determine the biology of the pest on a range of host plants. Regular field assessments over a prolonged period of time (in the tropics this would take at least a full year) are needed to measure fluctuations in the pest population and determine the presence and impact of any natural enemies on this process. These studies would need to be replicated on any other major plant hosts to determine if the development of pest populations is in some way synchronized with it.

Outbreaks of the *Huvani* are reported every year in the Maldives, however, they are not country-wide and appear restricted to several islands, atolls or regions at any time. This points to the influence of the local climate as well as the micro-environment as an important factor on population dynamics. With the large number of atolls and islands in the Maldives, it will be logistically and financially unfeasible to conduct surveys on every atoll. A compromise aimed at optimizing human resources and finances has been sought in this proposal, by establishing 2-3 study sites distributed over the Maldives. Wherever possible, the project will collaborate with and seek involvement from other relevant stakeholders to ascertain information exchange on the progress of the project.

The project will collect data on the seasonal abundance of the pest and its natural enemies to determine population dynamics and factors that influence it. These data provide crucial information that is required for the development of sustainable, integrated control measures based on an IPM approach that are appropriate for the Maldives.

In view of this, the following activities have been identified which are aimed at delivering the data to allow the development of an IPM programme.

1 Research on population dynamics of E. fraterna in the Maldives

Surveys will be conducted to monitor abundance of egg masses and pupae, and the presence and impact of natural enemies of the moth. They will be carried out for a minimum of one year but preferably two years, to gain an appreciation of the pest, its biology and ecology, and any interactions it has with its plant hosts, natural enemies, and the climate.

These studies will be carried out at least once a month on several atolls in the Maldives. A suitable location for surveys is Villingili island near Male', but some 2-4 other islands should be included as well. Islands will be selected as study sites, based on criteria that consider geographical spread (north, central and south), and reported outbreaks of *Huvani* in recent years, and the presence of weather stations where meteorological data are collected.

2 Research on appropriate control methods of E. fraterna

Control methods will be developed and tested for their effectiveness in contributing to maintaining populations of the pest at low levels, and / or controlling the pest during outbreaks. Specific emphasis will be on the complementary action of a combination of biological, chemical and physical methods in an integrated approach. Control methods that will be tested include light trapping, the 'burlap' method, pesticide application to house walls; and the bio-insecticide BTK.

These studies will be implemented on islands where the pest is sufficiently abundant to allow the acquisition of reliable and representative test results.

Project duration: 3 years

Tentative Budget: (Costs in USD)

Population dynamics studies

Travel to three atolls (monthly, for 3 years):		($)
Air travel (2 people. 12 trips p.p and p.a)	est.	30,000
Surface transport (boat, vehicle)	est.	20,000
Overnight allowances, per diems	est.	5,000
Equipment and Materials:		
Collection materials:	est.	3,000
Laboratory materials:	est.	3,000

Evaluation of control methods

Travel to 'outbreak' islands (3 years):		
Air travel (2 people; 20 trips)	est.	10,000
Surface transport (boat, vehicle)	est.	15,000
Overnight allowances, per diems	est.	5,000
Equipment and Materials:		
Equipment:	est.	5,000
Laboratory materials:	est.	2,000

Study Tours and Field Surveys of natural enemies in India, Pakistan, Sri Lanka

Travel (International)		
Air travel		
To and within India, Pakistan and Sri Lanka:		
(4 trips by 2-3 people)	est.	20,000
Surface transport (vehicle hire, fuel)	est.	20,000
Travel allowances, per diems	est.	20,000

Equipment and Materials

Field Laboratory, or laboratory hire	est.	10,000
Laboratory materials (cages, containers, etc.)	est.	10,000
Laboratory improvements – Male'	est.	15,000
Equipment, laboratory materials	est.	5,000

Technical Assistance

Fee International Specialist:		
6 months over 3 years (@ 12,000 per month)	est.	72,000
Per Diems: 180 days @ 100 per day	est.	18,000
International Travel: 12 trips @ 3000	est.	36,000
Technical assistance in India, Sri Lanka, Pakistan:		
12 months @ 2500	est.	30,000

Administration

Telecommunication	est.	5,000
Reporting	est.	5,000
Total		**281,000**

APPENDIX 3

Persons Consulted

Kamaludeen, Abdullah, Minister of Fisheries, Agriculture and Marine Resources

Zuhair, Mohamed, Mr. Executive Director, MFAMR

Naseem, Mohamed, Mr., Senior Horticulturist, Male' Municipality

Shafeeq, Ali, Mr., Assistant Director, Male' Municipality

Shaugee, Mr., Male' Municipality

Rasheed, Ishmail, Mr., MFAMR

Ali, Amir, Mr., MFAMR

Shafia, Aminath, Ms., Director of Agriculture, MFAMR

Tuitubou, Christina, Ms., Librarian, Secretariat of the Pacific Community, Suva, Fiji

Maddison, Peter A., Dr. Field Studies, Auckland, New Zealand