DEFOLIATION OF AN ECUADORIAN MANGROVE FOREST BY THE BAGWORM, *OIKETICUS KIRBYI* GUILDING (LEPIDOPTERA: PSYCHIDAE)

R. I. Gara,

College of Forest Resources, University of Washington, Seattle, WA 98195, United States of America

A. Sarango

Forest Protection Unit, MAG/DINAF Experimental Station, Conocoto, Ecuador

&

P. G. Cannon

Forest Research Institute, Private Bag 3020, Rotorua, New Zealand

Received November 1990

GARA, R.I., SARANGO, A. & CANNON, P.G. 1990. Defoliation of an Ecuadorian mangrove forest by the bagworm, *Oiketicus kirbyi* Guilding (Lepidoptera: Psychidae). A defoliation of mangrove forests by the bagworm, *Oiketicus kirbyi* Guilding, was reported on February 20, 1989 within the Ecuadorian Ecological Reserve of Churute. By mid-September, the population collapsed after defoliating about 1200 *ha* of the Reserve. Infestation spread was down wind; a pattern presumed to be caused by air borne larvae. Collapse of the outbreak was attributed to increased parasitism, avian predation, physiologically inferior adults (as assumed from decreased pupal weights), and lack of females in the most severely defoliated areas.

Key words: Mangrove forests - Ecuador - defoliation - Psychidae - *Oiketicus kirbyi* - natural control

Introduction

The mangrove forests of Ecuador are being decimated by a burgeoning shrimp industry. Their practice is to cut large openings within these brackish water forests to build holding ponds in which to rear larval shrimp. For over a decade, the Ministry of Agriculture and Animal Husbandry (MAG) has been trying to regulate this indiscriminate activity with little success. In 1977 the government recognised the need to protect at least a remnant of this unique estuarine ecosystem and established the Ecological Reserve of Churute which primarily encompasses a series of islands within the Bay of Guayaquil (Figure 1). The

principal mangrove species of the Reserve are *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus* (Anderson 1985).

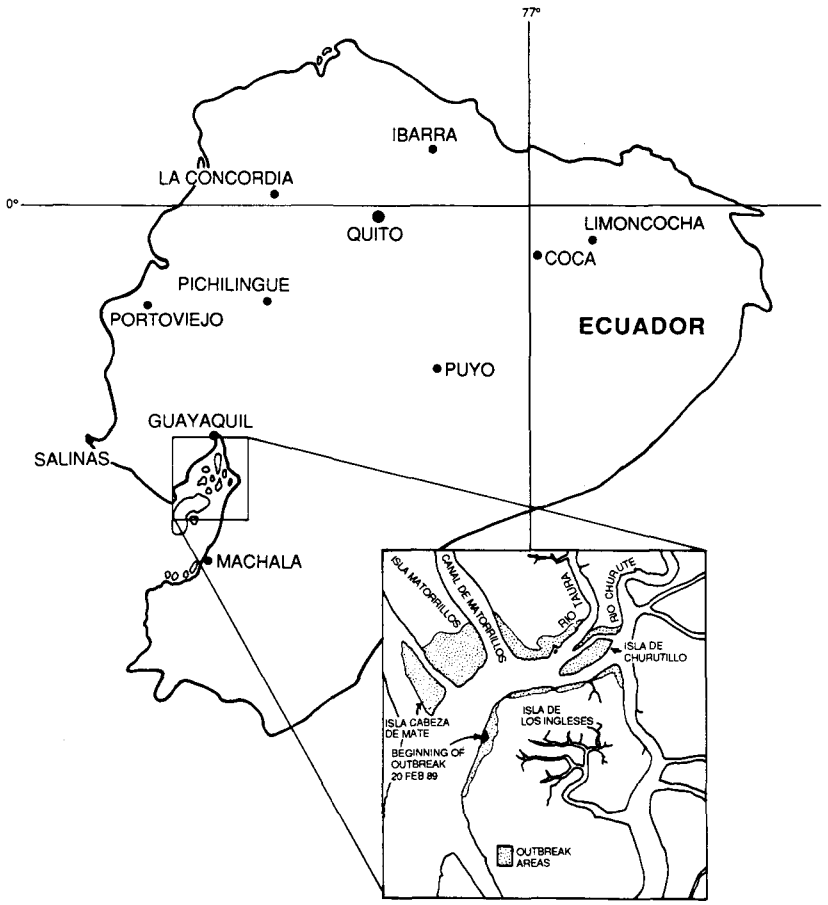

Figure 1. A map of Ecuador and the Ecological Reserve of Churute showing the extent of mangrove forest defoliation by the bagworm *O. kirbyi*

During February 1989, bagworm-caused defoliation of these forests was reported in the northeast corner of the Reserve's largest island, Isla de los Ingleses. By the end of June, the outbreak spread north and northeast in the direction of prevailing winds and included an area of *circa* 1000 *ha.* August and September trips to the infested zone showed that areas affected earlier were now completely defoliated and residual larvae were trying to survive by gnawing the bark of trees. Starting on July 19, larvae and foliage for larval rearing were taken to the Ecuadorian Forest Service's (DINAF) Forest Protection Unit laboratory in the town of Conocoto. The general objective of subsequent trips to the Reserve was to gain insights into natural regulation of the bagworm, *Oiketicus kirbyi* Guilding population - to ascertain if applied control would

eventually be necessary. Specific objectives were as follows: to determine degree of parasitism and parasitoid species effecting population control, and to estimate pupal weights and sex ratios of bagworms from defoliations of various severities.

Methods

We visited the Reserve on July 20 - 22, August 17 - 19, August 24 - 26 and September 11 - 13; in all cases larvae and mangrove foliage were brought back to the DINAF/Conocoto laboratory. There, larvae were placed into polyethylene bags along with a continuous supply of fresh *R. mangle* leaves and each bag then was tacked to a board located in a temperature controlled (27 - 30°*C*) room. Bagworm pupae were sexed and then weighed on an electronic balance. As insects (bagworm adults, parasitic wasps and other associates) emerged within the polyethylene containers, they were mounted, labelled and sent to the Smithsonian Institution for identification.

During the August 17 trip, larvae and pupae were gathered from four locations. The first sampled area was approximately 8 *km* up the Churute River from the most infested zone, the Churutillo Island, the others about 6, 1 *km*, and on the island itself, respectively (see Figure 1). The insects collected from Churutillo Island were found on the branches and stems of the completely defoliated trees. The idea behind these collections was to compare the quality of *O. kirbyi* populations emerging from an area of endemic populations with areas sustaining medium and outbreak population levels.

Results and discussion

R. W. Carlson of the USDA Systematic Entomology Laboratory, Plant Science Institute, identified the ichneumonids emerging from bagworm pupae as belonging to the genera *Chirotica* and *Neotheronia*. He suggested the tiny *Neotheronia* sp. may in fact be hyperparasitoids. Braconids collected were identified as *Diginogastra psychidophagous* (Blanchard) by P.M. Marsh of the same institute; and D.R. Davis of the Smithsonian Institution identified the psychids as *O. kirbyi*.

Although we were unable to determine instar numbers, we estimated that the psychids complete a generation in 30 to 35 days. We noted this from our rearings as well as from field observations, that is during our July 19 and August 24 trips most of our collected insects were in the pupal stage. Our laboratory rearings showed that males emerge about five days after the females; in fact, a portion of the male population seemed delayed by ten days or more.

On July 21 we made an ocular survey of preferred *O. kirbyi* host material along an 805 *m* transect next to the shore line of Churutillo Island. We estimated that *R. mangle* trees had about 80% of their foliage removed, *A. germinans* and *C. erectus* trees were about 10% defoliated and *L. racemosa* was least preferred as less than 5% of their foliage was eaten.

The down wind dispersal of the outbreak accounted for the 160 *ha* mth^{-1} northeasterly spread of the damage; a helicopter flight on August 17 showed that over 1200 *ha* had been defoliated since mid-February. By mid-September the outbreak stopped growing. In fact, during the September 11 trip, we observed large swarms of parasitoids flying around bagworms hanging from twigs, branches, and trunks of the defoliated forests. Barrows (1974), and Cox and Potter (1986) described the process of with-the-wind larval dispersal, "ballooning", for the bagworm *Thyridopterix ephemeraeformis* (Haworth). They point out that since psychid females are apterous, larval dispersal is a way to mix the gene as well as providing escape from zones of high competition, predation and parasitism.

There were pronounced differences in levels of bagworm survivorship, parasitism, pupal weights, and sex ratios with regards to collection date and location. Insects reared from the July collection on Churutillo Island had a mortality of about 65% and an average pupal weight of 0.45 and 1.17 *g* for males and females respectively. By mid-August, mortality of insects collected at the same place had increased to about 75% and the average weight of male pupae was 0.28 *g* and females 0.54 *g*. Bagworms reared from the September 11 collection had a mortality of about 90%, no females emerged, and average male pupal weight dropped to 0.20 *g*. Bagworms emerging from the July 20, August 17 and September 11 collections were 52.1, 91.4 and 100% males respectively (Table 1).

Table 1. Emergence, pupal weights of males (M) and females (F) as well as survival of *O. kirbyi* larvae (L), pupae (P) and adults (A) as determined from laboratory rearings of material collected from mangrove forests of the Ecuadorian Ecological Reserve of Churute

Date	Numbers						Dying (%)	Males (%)	Weight (*g*)	
	Dead			Alive					F	M
1989	L	P	A	L	P	A				
7/20	22	36	2	3	16	14	65	52.1	0.45	1.17
8/17	63	97	10	12	30	16	74	91.4	0.28	0.54
9/11	82	107	2	15	8	0	89	100	0.20	-

From the August 17 collection made at four different sites, we noted a 67.1% mortality among bagworms collected at Site I (8 *km* from the main outbreak) and later reared in the laboratory. This mortality increased to 83.3% when the bagworm origin was Site II (6 *km* from the outbreak); Site III (1 *km* from the outbreak) had an overall mortality of 97.2% and; most of the bagworms collected from Site IV (the Churutillo Island) failed to emerge: a mortality of 98.6% (Figure 2). An important mortality factor for the psychids along this transect was parasitism of larvae and pupae. For example, in Site I, 70.2% of the dead larvae had been parasitized as were 92.2% of the dead pupae. The effects of parasitoid pressure were even more rigorously felt at Site IV where 72.3% of the dead larvae and 98.1% of the dead pupae had been killed by parasitoids.

Our results indicate that collapse of the outbreak by mid-September was in part due to the augmenting parasitoid pressure as well as probable avian

predation as indicated by the torn silken cases (Johnstone 1981). Although, to a lesser extent, larvae were also killed by an entomophagous fungi; these dead larvae were hard and encrusted with whitish mycelia. However, unfavourable food quality, as the psychids were forced to gnaw on the tannin rich bark of stems and branches, was likely the decisive event in collapse of the population. This probability is noted in Figure 3, where the average weight of male pupae drops from 0.51 *g*, 8 *km* from the outbreak, to 0.28 *g* on Churutillo Island. Similarly, the average weight of female pupae along this transect drops from 1.2 *g*, 8 *km* away from the island, to 0.61 *g*, 6 *km* from the island; bagworms reared from the island *per se* were all males. These observations agree with Horn and Sheppard (1979), who state, "In the final year before extinction (of a population of *T. ephemeraeformis*), there were no adult females...in the population. It seems that though sex ratio may not have been a factor in the initial (population) decline, it hastened the final demise of the bagworms..."

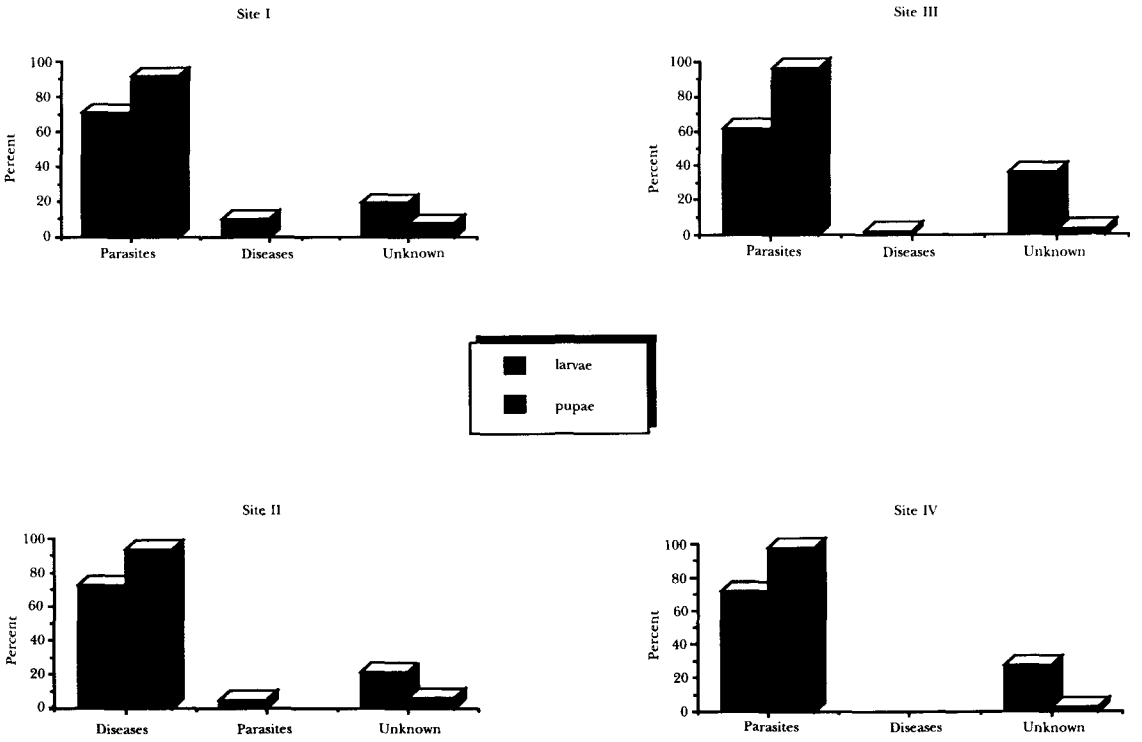

Figure 2. The percent of all the *O. kirbyi* larvae and pupae reared in the laboratory killed by parasitoids, diseases and unknown factors; insects reared were obtained from Site I, 8 *km* from the Island of Churutillo (a completely defoliated zone) as well as from Sites II and III which were 6 and 1 *km* respectively from the island, the island itself was Site IV

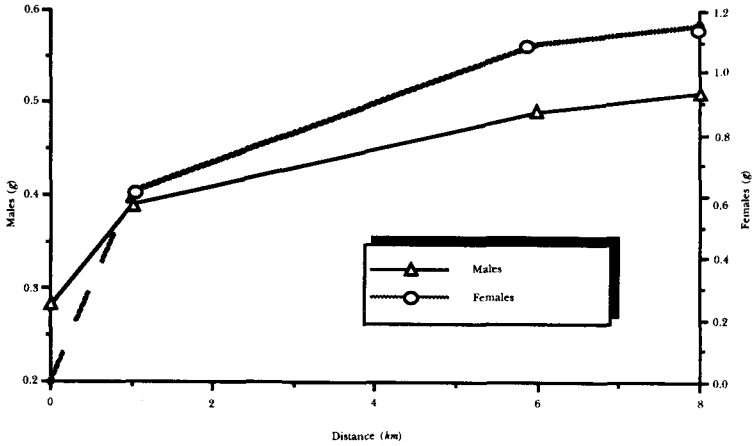

Figure 3. Decrease in weight of male and female *O. kirbyi* pupae reared from sites 8, 6, 1 and 0 *km* respectively from the Island of Churutillo, the most heavily defoliated area; no female pupae were collected from the island

We concluded that the psychid population was adequately controlled by competition factors, that is parasitism, poor quality individuals and lack of females in the most heavily defoliated areas. Accordingly, we advised MAG that applied control was unnecessary.

Acknowledgements

We thank R. Zambrano, a DINAF technician, for his ecological tour of the Reserva Ecologica de Churute and we appreciate the help of J. Woolfson and D. Lange in preparation of the manuscript. This study was supported by the USAID/MAG/DINAF Forestry Project.

References

ANDERSON, D. 1985. *Crecimiento y estado morfologico y estructural del bosque de manglar en la Reserva Ecologica de Churute.* Escuela Superior Politecnica Del Litoral. Guayaquil, Ecuador. Mimeographed. 34 pp.

BARROWS, E.M. 1974. Some factors affecting population size of *Thrydopteryx ephemeraeformis* (Lepidoptera: Psychidae). *Journal of Environmental Entomology* 3: 929 - 932.

COX, D.L. & POTTER, D.A. 1986. Aerial dispersal behaviour of larval bagworms *Thyridopteryx ephemeraeformis* (Lepidoptera: Psychidae). *The Canadian Entomologist* 118: 525 - 535.

HORN, D.J. & SHEPPARD, R.F. 1979. Sex ratio, pupal parasitism, and predation in two declining populations of the bagworm, *Thyridopteryx ephemeraeformis* (Haworth) (Lepidoptera: Psychidae). *Journal of Ecological Entomology* 4: 259 - 265.

JOHNSTONE, I.M. 1981. Consumption of leaves by herbivores in mixed mangrove stands. *Biotropica* 13: 252 - 259.