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Population dynamics of a fruit sucking moth, Othreis fullonia Clerck (Lepidoptera, Noctuidae) in New Caledonia.

P. COCHEREAU*

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Several species of big moths are armed with a strong proboscis which allows them to pierce the skin of a lot of succulent cultivated fruit and to feed on their juice during the night. Fruit, after being punctured in this way, are visited by a great number of commensal species and, invaded by fungi Oospora citri aurantii and diverse Penicillium, they decay on the ground.

We can point out the genus Calpe and Calyptra in Japan, Gonodonta in America, Achaea, Serrodes and Anua in Africa - mainly in South Africa - and overall Othreis and Eumaenas in the indo-australian-pacific area, but also in Africa about Othreis.

The attention is called to these moths through sudden outbreaks of caterpillars which thoroughly defoliate cultivated or wild plants, while important moth migrations can be observed from breeding sites to orchards, often very distant from one another. Moths may practically disappear from the field during a series of years, to reappear suddenly with outbreaks of caterpillars. Then we can hardly do something against the pest.

In New Caledonia, an island which lies in the Pacific ocean 2000kms off the Australian eastern coast, we have followed during thirty months the population fluctuations of a moth which is widespread everywhere under the tropics, except in America : Othreis fullonia Clerck. Its caterpillars generaly grow - specially in Australia - on different plants of the Menispermaceae family, but, curiously enough, in Pacific islands and New Guinea, that family is replaced by the Leguminosae family with the genus Erythrina ; this fact puts down the interesting problem of adaptation of phytophagous species to new host-plants. In New Caledonia, Erythrina trees

* ORSTOM Center, Po Box 4, Noumea, New Caledonia.

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are spread everywhere in the environment - sometimes they give small forests of tall trees - because they were formerly planted as shade-trees for coffee plantations and are still planted as hedges. Their soft wood does not allow any industrial use.

To follow the populations of the pest in New Caledonia we chose, in the middle of the island, a valley well isolated geographically, from the top of the valley situated at the level of the mountainous central chain down to the plain near the seashore, and along which is defined, on a small scale propicious for observation, an ecological gradient. This elementary isolation of the valley gives few interactions with the adjacent valleys. The valley so individualizes a fluctuating group of the insect to be studied, an elementary population which shows few contacts with other adjacent groups of the same species. That allows to define a life-system of Othreis fullonia and to study how it works.

So we have chosen twenty four biotopes all along the valley where a whole tree, or a hedge of Erythrina cuttings, or simply several big branches on big trees were selected for a continuous study. We visited these biotopes and these parts of a vegetation, on an everage every thirty days, during thirty months, which means about twenty three generations of Othreis.

Indeed Othreis does not show distinct generations because it grows in tropical climates, all the year round and shows, from this point of view, analogies with human populations or aphid populations in temperate climate. At the beginning of an outbreak, it is possible however to distinguish two well individualized generations with which the components of parasites and predators living on the spot may interfere, or not.

When sampling were worked out, the area was divided into three zones, one for tops of mountainous valleys, one for the narrow pass situated between the mountains and the plain and the coastal plain itself.

An important matter is that, for each survey, either concerning eggs, caterpillars or nymphs, no sample has been done ; "fresh" eggs, parasited, hollowed out by predators or momified by fungi were located on the leaf by means of a trace done with a sharp nail ; that allowed at the following survey to see what had happened with eggs filed at the former sampling and left on the same location ; so are suppressed some of the methodological and theorical inconveniences of a systematical sampling, and also a perturbation of the habitat.

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During normal years, populations of caterpillars and moths are very low. So, in 1968, losses calculated in an orchard of mandarin-trees reached 4 %, birds' and bats' depredations were at that tine much more important. But during outbreak year, as in 1969, losses from Othreis approached 100 %.

A whole complex of predators and parasites turns around the populations of eggs :

First, parasites :

Ooencyrtus sp. (Encyrtidae) mainly ; now Annecke is describing it ; it is by far the most important reduction agent ; we have studied its biology;

Then, Trichogramma australicum Girault

and Telenomus sp. (Scelionidae), these two latter parasites being much more scarce, chiefly the scelionid wasp ;

fungus Fusarium sp., is added occasionnally.

Then, predators which puncture eggs and draw off contents : larvae of Chrysopa noumeana Navas and Chrysopa otalatis Banks ;

two Lygaeid bugs : Nesogermalus pacificus Montandon
and Germalus montandoni Bergroth

and miscellaneous ants. But the part played by these ants, although it be sometimes important, is usually very low.

A very heavy mortality is then observed on 1st instar caterpillars as soon as they are born. We attach this fact mainly to the quality of food, the young caterpillars being unable to subsist - as laboratory experiments have shown - on old leaves. As soon as they are born they must go and search for young leaves and therefore they move towards the extremities of branches ; then they must be subject to predators, mainly bugs, chrysopids larvae and ants and mainly to climatic adverse agents (rains, dessication etc...)

The action of the small predators and birds as "lève-queue" (Rhipidura spilodera verreauxi, Muscicapideae) follows its course on 2nd and 3rd instars caterpillars, while enter the lists the wasp Polistes olivaceus De Geer (Vespidae), very seldom the mantid Tenodera costalis Blanch and the Asopinae bug Platynopus melacanthus Boisd. On the 5th instar larvae a Tachinid fly just described by Mesnil, lays eggs : Winthemia caledoniae. We have studied its biology and its egg-laying behaviour in front of its larva-host. Birds and Polistes can also attack nymphs.

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At the beginning of the year 1969, we locked on very important outbreaks of Othreis. They were preceded by a very heavy drought for the ten months which have gone before the demographic explosion. We have studied this climatic perturbing factor over several years of outbreaks yet reported, so that it may be possible to foresee future outbreaks.

- During december 1968, in the area where outbreaks will happen (plains near the sea-shore), a very small number of fresh eggs are to be found and even some first instar larvae, but in very localised biotopes (humid biotopes, hedges, shoots on a cut tree etc...) ; everywhere else, there is nothing, and the egg-parasite Ooencyrtus sp. cannot be seen. Moreover very few fruit are available in this habitat, food for the moth is scarce and its fecundity rate is very low. Drought has changed this environment into a desert, at least with regard to Othreis.

- in january, few eggs are found, but Ooencyrtus is present all the same in some locations ; some young larvae are also noted, but no nymph, while some are found up in the valley : these are the source of outbreaks which are getting ready ; however the hypothesis of a summer diapause of a part of moth population against drought is not excluded, a diapause which should be broken by the rains coming.

- after rains have come, huge layings of eggs are seen from moths coming down from the valley. In the same time guayava, jamboses (Eugenia jambosa L., Myrtaceae), miscellaneous Ficus fruit and the first oranges are suddenly available in the environment, as much plentiful food for these first moths ; therefore the fecundity rate rises. Eggs are laid down on Erythrina trees, mainly as masses of 100 to 200 eggs, instead of single eggs. A low population of moths initiate these first layings of eggs, but the fecundity of a well feed moth can reach 1000 eggs. In some locations, Ooencyrtus, which has subsisted against drought and lack of Othreis eggs, parasites egg-masses successfully and biological control is established very fast ; on the other hand, in pockets (drier biotopes remained ecologicaly free from Othreis during several consecutive months and where Ooencyrtus does not act) outbreaks of larvae happen, firstly temporary, because the predators on larvae, wasps and birds, destroy them very fastly. In the plain - and very occasionally in the gorge (biotope 15) -

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these temporary outbreaks occur mainly in homogeneous settlements of Erythrina indica, tall trees which can reach 10 meters high. During that time, biological control is continually effective, along the narrow pass and in the valley to the mountains, thanks to Ooencyrtus and to predators.

Besides, larvae in outbreaks are only dark-coated - while during periods of low populations they are green or yellow -, they are more active during the day, they grow more rapidly and, as the nymphs, they show a smaller size ; a group effect is sure. These events are very fugitive ; for example in biotope 20 it has been possible to look on a parasitism of egg masses established up to 80 % while at the same time 348 caterpillars of 3rd, 4th and 5th instars were counted on adjacent branches. An additional fact can also occur in the successful development of 1st and 2nd instar larvae : the lot of young leaves shooting up, after rains have come, after a long drawn out drought, itself the source of a complete fall of the leaves of two species of Erythrina among three. The natural mortality of 1st instar larva (in percentage) is identical in 1969 to that of other years and the great number of individuals which suits the same percentage of survival is the origin of outbreaks ; that percentage in normal year suits a low population, easily jugulated by predators. Besides, a very light decline in the 2nd instar larvae mortality happens, a low percentage but which suits an important population of additional caterpillars, if it is considered that their absolute density goes ut from 1 to 12 at least in 1969 compared with 1968.

Afterwards, even in biotopes where biological control is effective, a small number of unparasited nymphs are produced, in spite of Ooencyrtus parasitism on eggs and predators' activity on larvae. The new generation is shown first with always localised outbreaks, but more numerous and severe, only in settlements of tall Erythrina trees and in the plain. If they are present, predators are then not able to destroy the whole. One may observe that, in front of pleutiful preys, their predator - behaviour is changed : the birds Acridotheres tristis congregate into unusually massive flights, constitute noisy dormitories in the evening and, as well as the wasps, practice a systematical carnage of the caterpillars, which cannot be caused by hunger.

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So, the natural parasitic components being at one time literally overwhelmed by the important aggregate of the caterpillars, outbreaks sprawl over the whole coastal plain, for about two weeks, till complete defoliation of the important settlements and small forests of Erythrina trees takes place. At that time, intense competition for food can be observed and at the end of the gradation the mortality is complete for thousands of larvae.

We have been able to observe in a tangible way the resistance of the environment against outbreaks, within the area lying between the gorge and the plain, all along a distinctly delimited boundary, where could be noticed a sudden transition from overdefoliated Erythrina trees to others on which foliage had been preserved.

The populations of just born moths fly around and feed, on the plain at first (in La Foa orchards), spread on an homogeneous manner flying up the valley and suck all available fruit (citrus, tomatoes, melons etc...) in a percentage near 100 %. At the same time they lay eggs on Erythrina trees, where the opponent agents are now wholly playing their part.

At this time however, can be constitued far up the valley small pockets of caterpillars outbreaks, very localized, where Ooencyrtus can have been missing. Indeed, when the outbreaks of moths increase enough so that all the biotopes where eggs can be laid, may have harboured at least one using attempt by a egg-layer female moth, these biotopes usually free from Othreis so turn out to be chosen and brought to light very naturally ; a few nymphs are produced but outbreaks cannot spread out there, either because the small amount of food is fastly used up or because the parasitic components are fastly settled.

It must be pointed out that on 1970 (1969 was a dry year also) these processes began in the same manner, although the concerned populations have been 50 % less. But the important Polistes populations bred on larvae outbreaks in 1969, gave in 1970 a sufficient posterity to jugulate the first pockets of outbreaks.

That gradation can be summed up tinto four periods :

1° - Extreme climatic conditions (a very long drought) during which Othreis finds shelter and subsist in the mountains, but very weakly in the plain.

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2° - When rains come, coinciding with a lot of food (fruits), a small population of Othreis migrate from the mountains to the plain, as they lay heavy masses of eggs on Erythrina trees and they suck the first fruit available in the plain.

3° - In the plain only, an ecological habitat left free during a long time by the pest, antagonistic factors of the environment do not ultimately succeed in jugulating Othreis caterpillars outbreaks ; a complete defoliation of the host plants follows, then all larvae die from lack of food.

4° - The production of moths spread out everywhere, especially they fly up the valley sucking the whole crop of fruit.

These elementary events observed in one selected valley assimilable with relative values, are on absolute value generalizable to the whole island New Caledonia, itself assimilable to a closed system where hundreds of Erythrina trees hectares were defoliated in April 1969.

To conclude, the egg-parasite Ooencyrtus performance is linked with a strict phenological coincidence in space but also in time of parasite populations with Othreis fesh eggs : when outbreaks start, two individualize generations of moths are exceptionally looked on, of which a part of the egg-masses does not coincide with a sufficient number of parasites being present ; indeed the development of Othreis eggs lasts 4 to 5 days only, while that of the egg parasite is 18 days. With regard to the predators, beyond a somewhat exceptional density of the preys, they all become momentarily unable to reduce this pest outburst ; birds, as well as the wasp Polistes are ineffective then.
On the other hand, the pest physiology and its migratory behaviour prove to be of prime importance.

At last, an intraspecific competition is looked on only when the population reaches an alarming level, when it consumes nearly its whole food ans when it is near collapsing, from this last fact. Hence, it is an extreme situation.

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An outbreak of Othreis is equivalent to a crisis of the ecological system which is studied ; the ability of this system in overcoming this crisis - ability produced by the parasitic components - collapses when phenomena are enlarging and reach an alarming level. Yet, we have there to link the notion of level of crisis to that of scale of time, for that level to be reached and the crisis to happen. This leads to the projection and the management of such crisis, or better, to managing the populations which are concerned. But, the future in that field is not necessarily given befofehand and discovered - as showed the year 1970 with the Polistes effective work - and try to predict this future with assurance certainly remains presuming. On the other hand, it is certainly easier to manage it in conducting attacks against known grounds. That concerns an other paper.

The pockets of outbreaks also allow to consider the whole population of Othreis as groups of individuals whose environment is distinct, since it happens, only in these pockets, an important phenological break, by the fact of the temporary lack or presence of the different recorded factors. And only these groups of individuals are the origin of a general crisis.

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P. COCHEREAU

Population dynamics of the fruit-sucking moth Othreis fullonia (Clerck) (Lepidoptera : Noctuidae) in New Caledonia.

A three-year study was made in New Caledonia of population fluctuations of Othreis fullonia on the larval host plant (Erythrina) in an isolated valley, from which seasonal migration occurs. In a normal year damage is minimal, populations being limited by three species of hymenopterous egg-parasites, an egg-infecting fungus, several hemipterous and chrysopid predators, Polistes olivaceus (De Geer)(Vespidae), and Winthemia caledoniae Mesnil (Tachinidae), which parasitizes the larvae.

An abnormal year follows severe drought at the beginning of summer, when Othreis deserts the coastal plains and migrates to mountain valleys. Its population density is now low, but with the rains migration occurs to the coastal plains, where the moths lay eggs on the larval host plant. At this time oviposition does not coincide phenologically with the presence of egg-parasites, and a population explosion follows. Drought and the absence of egg-parasites, mainly Ooencyrtus sp., are the key factors in the population dynamics.

Population management of the fruit-sucking moth, Othreis fullonia (CLERCK) (Lepidoptera : Noctuidae), in New Caledonia.

After severe drought in New Caledonia, large infestations of Othreis larvae can occur in the coastal plains, because the activity of an egg-parasite, Ooencyrtus sp. (Encyrtidae), fails to coincide with heavy oviposition by the moth. The adults of these initial outbreak populations disperse along the coast or up the mountain valleys, spreading the infestation while searching for fruits to suck.

It was possible to prevent egg-laying, and thus avoid the development of a second generation in the uplands, by locally destroying the moth's obligatory host-plant, Erythrina (Leguminosae). Invading females were turned away by the lack of oviposition sites, and males may have followed. A good crop of mandarines was produced thereafter in the treated area, whereas losses approached 100% elsewhere.

The same experiment is being conducted on a large scale in the Loyalty Islands (Lifou).