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BIOLOGICAL CONTROL OF MITES IN GLASSHOUSES

By

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The area of glasshouses has increased rapidly the past decades and is still increasing. It is estimated that at the moment the total area all over the world is about 30.000 acres. The greater part of this is used for the production of vegetables, mainly tomato, cucumber and lettuce. A great variety of flowers are grown under glass and especially the acreage of roses, carnations and chrysanthemums has grown very rapidly in recent years. Fruit growing has been decreasing for many years already and no more than about 1.000 acres of these crops now remain.

The modern glasshouse industry is characterized by a high level of intensification and specialization. The year-round production of cucumbers and chrysanthemums are examples of this development. As a consequence however pests and diseases have become more serious and spider mites especially constitute a very great problem. Chemicals have to be applied more frequently and resistance is built up very rapidly under these conditions. Many of chemicals used for the control of red spider have now failed to give sufficient control due to resistance (Bravenboer and Theune, 1961, Helle, 1965). It is therefore understandable that there is a growing interest in biological control of spider mites in glasshouses.

Two predators were found to be endemic in fruitgrowing under glass: the coccinnelid *Stethorus punctillum* Weise and the phytoseïid *Typhlodromis longipilus* Nesbitt (Bravenboer, 1959). About ten years ago a new predator *(Phytoseiulus riegeli* Dosse) found by Dosse (1958) gave very promising results in several experiments (Bravenboer and Dosse, 1962, Böhm, 1966, Chant, 1961, Hussey, 1964, Legowski, 1966).

In the following a survey is given of the possibilities of biological control of spider mites in glasshouses. This paper is divided into three parts.

1. A theoretical part.
2. An experimental part.
3. A practical part.

1. *Theoretical part*

From the biological point of view a glasshouse can be looked upon as an island. And in general biological control has achieved most success on islands. It means that immigration

Table 1. Biological data of *T. urticae* and three of its predators

	Development in days		Average egg production	Maximum number of prey destroyed per day	Hibernation
	20°C	25°C			
T. urticae	18	10	100	—	adult
S. punctillum	26	14	100	200	adult
T. longipilus	9	4	50	10	adult
P. riegeli	10	5	100	30	no hibernation

and emigration is very low and both prey and predator are more or less fixed to a certain area. This isolation was demonstrated by HELLE (1959), who found that spider mites inside the glasshouse were resistent to organophosphorus compounds, whilst the mites outside the house were non resistent.

To achieve effective biological control it is of importance that the biology of the predator shows as much similarity as possible to that of the prey. In Table 1 some biological data of the three above-mentioned predators and the prey are given.

As the development of *S. punctillum* is relatively slow in comparison to that of *T. urticae*, the build up of its population will proceed slower than that of the mite. The predator can destroy a large number of mites and to prevent starvation it also needs a fair amount of the prey. This means that effective control can be expected only at high population densities of the spider mites. Being able to fly is an advantage to *S. punctillum* as in this way it easily follows the distribution pattern of its prey. The life cycle of *T. longipilus* is much shorter than that of *T. urticae*, which may result in a quick build-up of high populations. This advantage is however partly nullified by the relatively low egg production. Moreover *T. longipilus* has a low prey consumption capacity and moves rather slowly. So it can only control locally low densities of spider mites and will fail to do so if the population of the mite is higher and distributed all over the glasshouse. Both *S. punctillum* and *T. longipilus* possess the advantage of the same ability to hibernate in the glasshouse as *T. urticae*.

The development of *P. riegeli* proceeds much quicker than that of *T. urticae*. As the number of eggs laid by this predator is about the same as that of the mite, it is able to build up high populations in a very short time. Furthermore it is highly mobile, resulting in an effective searching capacity. It can follow the distribution pattern of the mite fairly well if the distance between one infested spot and the next is not too great. If sufficient food is available, *P. riegeli* can destroy a fair number of spider mites. Consequently *P. riegeli* can cope with both higher and lower densities of the prey. A disadvantage is that it does not hibernate under the conditions prevailing in the glasshouse and therefore it has to be repeatedly introduced.

A different aspect of glasshouse production in relation to biological control is the relatively small number of pests and diseases that occur under these conditions. The number of pesticides used is therefore restricted and those chemicals can be selected that are harmless to predators and parasites.

Summarizing it can be stated that theoretically the biological control of mites in glasshouses seems very possible.

2. *Experimental part*

Although the biology of both *S. punctillum* and *T. longipilus* has been studied thoroughly, there have been few experiments under practical conditions to introduce these predators (BRAVENBOER, 1959). The results indicated that success might only be expected in special cases. *S. punctillum* for instance will only be effective at high population densities of spider mites. This, however, involves risks as to economic losses. To prevent this, additional application of selective acaricides is generally necessary. Another restriction for the use of this predator is the fact that *S. punctillum* cannot live on plants with hairy leaves such as those of cucumber. Both the larvae and adults stick to the hairs and die of starvation.

Results of experiments with *Typhlodromus* mites have given contradictory results up to now, but in general they have not been very promising.

In recent years many experiments have been carried out in several countries to test the efficiency of *P. riegeli* as a predator of spider mites in glasshouses. In all cases the results can be considered as very promising.

Beside studying the biology (BRAVENBOER and DOSSE, 1962), the population dynamics of *P. riegeli* and *T. cinnabarinus* has been the main item of the research at our station. During six years experiments were carried out on young peach trees, isolated in cages to prevent emigration and immigration of both prey and predator. In nearly all cases the initial population of *P. riegeli* has been one female per 10 leaves, whilst the initial population of *T. cinnabarinus* varied from onr individual to about 800 per leaf. In all experiments

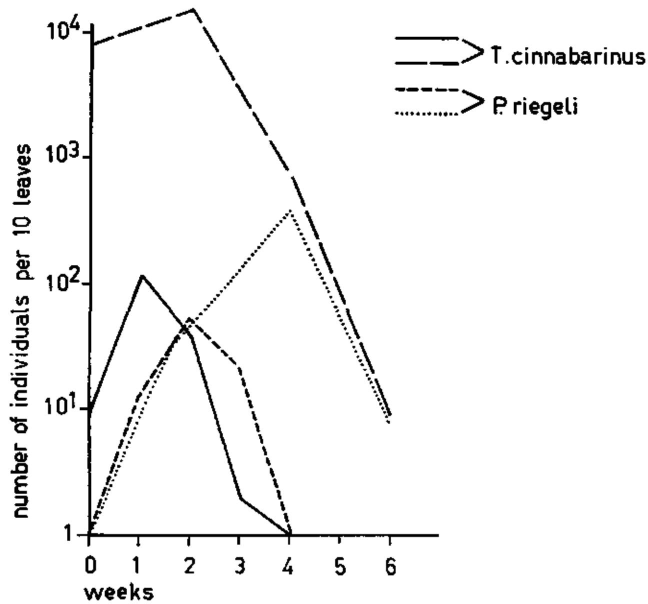

FIG. 1. Development of populations of *T. cinnabarius* and *P. riegeli*

the population of the spider mite was reduced by the predator to very low levels within 4—6 weeks after the beginning of the experiment. Figure 1 gives the results of two experiments, one with a very high initial population of the prey and one with a low initial population. The initial population of *P. riegeli* was in both cases the same. On the heavily infested tree (more than 800 individuals per leaf) *T. cinnabarinus* was practically eliminated by *P. riegeli* within 6 weeks. In the case of the low density the prey was reduced by the predator to practically zero within four weeks. Although the predator can cope with any population density of the prey it is however advisable to introduce *P. riegeli* at relatively low densities of the spider mites; MORI and CHANT (1966) found in accordance to our own experience that at high densities of prey the efficiency of the predator decreases.

It is very difficult to find the right moment to introduce *P. riegeli* into a population of spider mites. This is demonstrated in Fig. 2, giving the results of two experiments in which the initial populations of prey and predator were the same (1 per 10 leaves for *P. riegeli* and 20 per leaf for *T. cinnabarinus*). In one experiment the population of the spider mite did not increase at all and after three weeks nearly all the mites had been consumed. In the other experiment the population of *T. cinnabarinus* increased to a relatively high level during the first three weeks and was eliminated during the next three weeks. This phenomenon has been observed in several other experiments at different population densities. It is not possible to give an explanation for it. Temperature, humidity, composition of the population of the prey and other yet unknown factors may play a role in these varying results. Whatever the explanation may be, we will have to deal with these factors under practical conditions and these factors cannot be altered. Consequently it will not be possible to predict the maximum population given a certain initial population

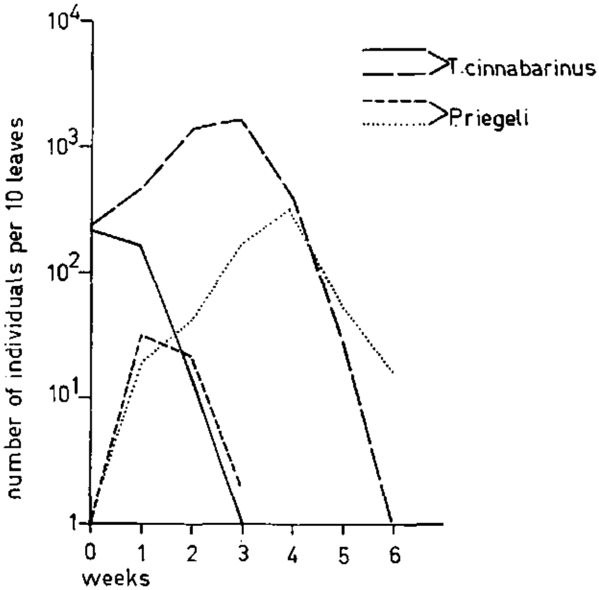

FIG. 2. Development of populations of *T. cinnabarius* and *P. riegeli*

density of the spider mite or given a certain ratio between prey and predator. This means that the maximum tolerable population level may be surpassed and additional application of acaricides will be necessary. Therefore the effect of acaricides on *P. riegeli* must be known. As other pests and diseases have to be controlled chemically, the toxicity of insecticides and fungicides to *P. riegeli* has to be studied too. In the literature little information is available up to now (SMITH c. s. 1963, HERNE and CHANT, 1965, BÖHM, 1966).

The results of our research in this field are given in Tabie 2.

It is evident that most of the specific acaricides are harmless to the mobile stages of *P. riegeli*. It will however be an advantage if the spider mites that are killed by the chemical still can be used as a source of food by *P. riegeli*. We investigated this possibility

TABLE 2. Toxicity of some pesticides to mobile stages of *P. riegeli*

Highly toxic	Moderately toxic	Slightly to non-toxic
Parathion	Kelthane	Dimite
Phosdrin	Lindane	Chlorobenzilate
Perthane	D.D.T.	Aramite
Zectran	Isolan	Pentac
Sevin	Morestan	Tedion
Undeen		Nicotine
Pyrethrum		Karathane

and choose for this purpose the ovicide Tedion (tetradifon). After treating eggs of *T. cinnabarinus*, females of *P. riegeli* were introduced and the number of eggs eaten by the predator was counted as well as the number of eggs laid by *P. riegeli*. The predatory mite was introduced directly after the treatment of the spider mite eggs and 1, 2, 3, 4 and 5 days after the application of tetradifon. The same was done with non-treated eggs of *T. cinnabarinus*. Table 3 summarizes the results of this experiment.

TABLE 3. The effect on predation of 15 females of *P. riegeli* on tetradifon treated eggs of *T. cinnabarinus*

Days after treatment	Tetradifon treated		Non treated	
	Number of eggs of T.c. eaten by P.r.	Number of eggs laid by P.r.	Number of eggs of T.c. eaten by P.r.	Number of eggs laid by P.r.
0	276	25	357	30
1	306	41	265	37
2	346	45	397	48
3	223	38	289	47
4	415	48	451	41
5	441	12	430	22

It is clear from these figures that *P. riegeli* cannot only live on eggs killed by the chemical, but the egg production also goes on uninterrupted for at least 5 days after the eggs of the spider mites were treated (the untreated eggs had nearly all hatched after these five days).

In an integrated control program this is of great importance as the chance of survival of the predator increases greatly in this way. Experiments with other selective acaricides (with no ovicidal action) were less promising and it may be expected that only ovicides can be used for this purpose. If other pests have to be controlled insecticides with no residual action could probably be used. The active stages of *P. riegeli* will be killed then, but the eggs might escape and give rise to a new population of the predator.

Little is known up to now about the dispersal of *P. riegeli* under practical conditions. In a preliminary experiment a few cucumber plants in the centre of a glasshouse were infected with *T. cinnabarinus*. Some weeks later *P. riegeli* was introduced on these plants and at the moment the predator had built up a high population, cucumber plants at different distances from this centre were infected with the spider mite. At regular intervals the dispersal of the predator was controlled. The results showed that *P. riegeli* reached all the places on which *T. cinnabarinus* was introduced. The longer the distance from the point of introduction however, the longer it took before the predator had reached the place. Under the conditions prevailing in this experiment, economic damage by the spider mite was done if the distance between the point of introduction of *P. riegeli* and the red spider infestation was more than 10 meters. This means that in practice the natural distribution of the predator is not sufficient and consequently the grower has to play an active role in its dispersal.

3. *Practical part*

In flower growing under glass biological control of spider mites has in general very little possibilities. As in most cases the grower not only sells the flower but also the leaves belonging to this flower, damage of mites on the leaves cannot be accepted. The difference in price between an undamaged plant and a slightly damaged plant is too great to take any risk. Possibly *P. riegeli* can be used as a "household insecticide", as nearly every housewife is troubled by spider mites in the perenial ornamentals in her house.

In fruitgrowing under glass *S. punctillum* and *T. longipilus* are endemic and if selective acaricides and insecticides are used, the number of applications of these chemicals can be reduced greatly. This method is followed on several holdings in Holland. Introduction of *P. riegeli* in fruitgrowing under glass is difficult as *T. urticae* hibernates scattered all over the glasshouse and due to differences in temperature at the hibernation places, the reappearance in spring takes place over a long period.

In vegetable growing under glass the value of *S. punctillum* and *T. longipilus* is of little or no importance. Nearly all the vegetables attacked by spider mites have hairy leaves and the beetle can hardly colonize these plants. As already stated the effect of *T. longipilus* is doubtful and there does not seem to be any possibility for practical application. The future of *P. riegeli* as a biological agent seems to be more promising, especially in cucumber growing. Reports in growers journals have already appeared (Anon., 1966a) and it is even being commercialized (VOGEL, 1965). However precautions must be taken to prevent failures and a good working system has to be developped. For Dutch condition the following method is probably the safest. In a cucumber house the natural infestation with spider mites occurs on a few plants scattered over the house. When the population has reached a level of a few hundred individuals (including eggs) per leaf a limited number of *P. riegeli* (about five per leave) is introduced on the infested plant.

On these plants *P. riegeli* will build up and after 4—6 weeks a high population of the predator will be present. From these plants *P. riegeli* can be distributed to other plants that have eventually become infested with red spider. This, however, means that the grower has to follow very carefully the development of both prey and predator. He has to look for new infections in his cucumber house several times a week. He has to decide at what moment *P. riegeli* is to be introduced and if an additional chemical treatment is necessary. This should not to be too difficult for a research worker who has nothing else to do than to look at spider mites, but for the average grower who has to deal with many other questions, this is a far from easy task.

A somewhat different system is to infest spider mites on the young cucumber plants and to introduce *P. riegeli* later on. In my opinion this is somewhat more dangerous. As I have shown above, it can up to now not be predicted how the populations will develop. This means that high populations of spider mites might occur and high populations are always difficult to control, whether chemically or biologically.

A special field of application could be the use of *P. riegeli* in the breeding of insects such as aphids. Chemicals can in general not be used and as has been demonstrated (KOCH, 1965). *P. riegeli* can solve this problem quite easily.

To finish I should like to say this. Although I am well aware of the resistance and the residue problems, chemical control is for the grower still a good and reliable tool. Biological and integrated control is much more difficult for the average grower. A system that is good, may fail because it is not used in the right way. This must be prevented, otherwise things will happen such as I read last year in a British growers journal: "Devon grower reports victory for red spider over predator" (Anon., 1966b).

SUMMARY

From a theoretical, experimental and practical point of view the possibilities of biological control of spider mites in glasshouses are discussed. Theoretically a glasshouse is a suitable unit for biological control. Of the predators *Typhlodromus longipilus*, *Stethorus punctillum* and *Phytoseiulus riegeli* the two last mentioned are the most efficient ones.

Experimentally *P. riegeli* has given very promising results in several countries. The practical application of this predator, however, must be handled with great care. More

information about the relation between prey and predator is still needed to prevent failures if the grower himself is going to use this biological tool.

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