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The importance of humidity in the development and spread of *Amblyseius andersoni* Chant (Acarina Phytoseiidae)

Abstract - For years it has been known that *A. andersoni*, taken from the Po Valley (where it has been widespread for some time) to the orchards in the Montpellier area, responded positively in the presence of prey but then declined from June on. The reason for this was sought 1) through laboratory research to determine the humidity needs of this species and 2) by comparing the climatic conditions of the country of origin and that of introduction. The laboratory experiments were carried out by exposing overwintering females in diapause to 50%, 60%, 70%, and 80% RH and temperatures of 20 and 25 °C. It was found that the mortality of the females decreases as the RH increases, that the critical threshold lies between 70% and 80% RH, and that 80% RH is the optimum level for *A. andersoni* to live and develop. The comparison between the variations in RH in the Po Valley climate and in that of the Montpellier area shows that in the latter the humidity level is lower than in the Po Valley. We can therefore presume that the cause of the failure of *A. andersoni* to survive in the new habitat is its intolerance to low humidity in certain months of the year, as has been demonstrated for other species. The difficulty in evaluating the actual humidity to which the species is subjected in the climate of the new habitat is discussed.

Riassunto - *Importanza dell'umidità nello sviluppo e nella diffusione di* Amblyseius andersoni *Chant (Acarina Phytoseiidae).*

È osservazione di piú anni che *A. andersoni* trasportato dalla Pianura Padana (dove è diffuso da tempo) nei frutteti dell'area di Montpellier, dopo una prima risposta in presenza di preda, dal mese di giugno declina; si ricerca qui la causa dell'insuccesso: 1) con indagini di laboratorio sulle esigenze di umidità di questa specie; 2) con il confronto fra le condizioni climatiche del paese di provenienza e quello di introduzione. La ricerca di laboratorio si è svolta esponendo femmine svernanti in diapausa a 50, 60, 70, 80% RH e a temperature di 20 e 25 °C. Si è rilevato che la mortalità delle femmine diminuisce con l'aumentare dell'UR, che la soglia critica si trova fra 70 e 80% UR e che l'80% UR è il livello ottimale per la vita e lo sviluppo di *A. andersoni*. Il confronto fra le oscillazioni dell'UR nel clima della

Valle Padana e dell'area di Montpellier rileva che in questa località il livello di umidità è spesso molto piú basso di quello della Valle Padana. Si suppone pertanto che la causa della mancata affermazione di *A. andersoni* nel nuovo habitat sia l'intolleranza alle basse umidità in alcuni mesi dell'anno, analogamente a quanto è stato osservato per altre specie. La difficoltà di una valutazione della reale umidità cui è soggetta la specie nel clima del nuovo habitat viene discussa.

Key words: Phytoseiidae, *Amblyseius andersoni*, humidity, survival.

INTRODUCTION

The importance that the climatic conditions (especially humidity and temperature) of a region have on the development and activity of populations of phytoseiids has been studied by various authors; humidity and temperature have been considered selective factors for these populations (Tanigoshi, 1981; Sabelis, 1985). Interspecific differences are generally deduced from field studies with the aim of finding a relationship between spatial distribution and climatic conditions in a certain area, and from laboratory research on the resistance of eggs to different levels of relative humidity (McMurtry et al., 1976; Stenseth, 1979; Sabelis, 1985; Bounfour et al., 1987; Croft et al., 1993). Research has been conducted on the eggs because the mobile life stages ingest water or sap, thus influencing their humidity conditions; in any case this is an indicative datum, especially when a comparison is made among different species.

Research on resistance to low humidity rate has also been made on *Amblyseius andersoni* Chant (=*potentillae*) which, as is known, is an important species both because of its distribution and characteristics: the efficacious biological regulation of phytophagous mites; the capacity to live and reproduce on the host plant even in the absence of prey by feeding on the sap of the plant (Ivancich Gambaro, 1986, 1988); facility in segregating OP-resistant populations (Dunley, 1991); lastly, ecological characteristics such as its high reproductive potential, voltinism, and tolerance to low temperature. The effects of RH on this species, especially on the development of eggs, have been studied by McMurtry et al. (1976), Sabelis (1985), and Croft et al. (1993).

McMurtry et al.'s research is of particular interest here, as it compares two biotypes, one from the Netherlands and the other from Italy (Fondi, Latium); by observing the hatching of the eggs in different RH conditions (20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%) at a temperature of 23 °C, these authors found that at 70% RH, 100% of the eggs belonging to the strain from Italy

hatched, while only 50% of the eggs of the Dutch strain did so. They concluded that this difference demonstrates that the resistance of the phytoseiids depends on the humidity conditions in their respective geographic areas of origin – a theory sustained and proved in the case of other phytoseiids (Bounfour et al., 1987; Van Dinh et al., 1989, and other authors).

Research concerning the relationship between RH and the hatching of *A. andersoni* eggs was recently taken up by Croft et al. (1993), who compare the response to RH of strains of *A. andersoni* from Oregon (U.S.A.), the Netherlands and Italy (Po Valley). In contrast with the finds of McMurtry et al. (1976), these authors see no difference in the response of the three biotypes,

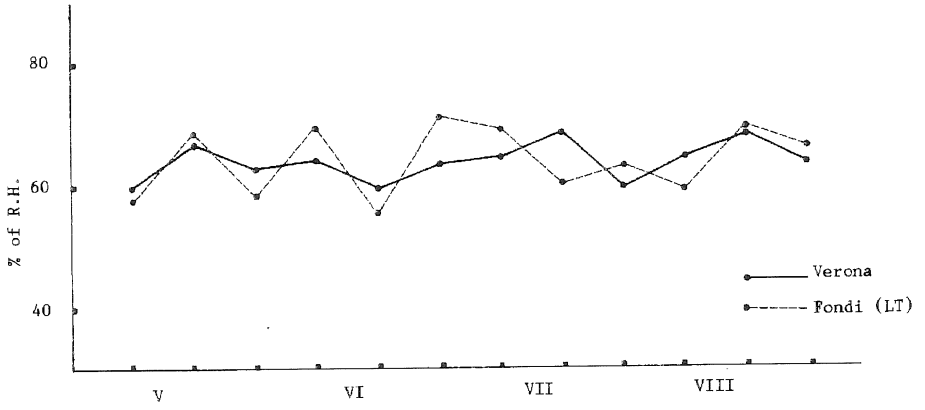

Fig. 1 - Average ten-day period RH in the climate at Fondi (Latium) and in the Po Valley (Verona), May-August 1989.

despite their different area of geographic origin. They state that although the strains studied by McMurtry et al. and themselves were both Italian, they come from different areas: the first from Fondi (Latium), at a latitude of 41° 12′, which Croft et al. (1993) suppose is «considerably drier» and warmer; the second from the Po Valley, at a latitude of 45° 26′, However, it must be pointed out that the climate in these two areas (Fondi and Verona) presents no difference in RH and in temperature; contrary to what Croft et al. suppose, Fondi is not in a dry area, as it lies along the coast. The RH conditions of these two localities can be seen in the data in Fig. 1.

My laboratory research on the response of *A. andersoni* to RH takes into consideration the stage of overwintering females in diapause, since this is the only stage besides the egg stage in which the humidity conditions are not influenced by diet.

The response of the females to different RH conditions certainly has a merely indicative value and it is therefore only a further confirmation of the studies made by other authors on eggs concerning the humidity needs of this phytoseiid.

MATERIALS AND METHODS

The research was carried out on overwintering females gathered from peach trees in orchards in the Verona area (Po Valley) during the months of November and December. The females were collected in band-traps tied around large branches and the stem of the host plant in the second and third 10-day periods of September.

The females taken to the laboratory were kept in constant light (8-16 hours), temperature (20 and 25°C) and RH (50%, 60%, 70%, 80%) conditions. The females used for the experiments were placed in small Petri dishes (diameter 5 cm) surrounded by a glue barrier and wrapped in a plastic (polythene) bag to maintain a constant humidity level. The temperature was automatically programmed and lighting came from a 20W cold light fluorescent bulb.

The females were placed in the Petri dishes in groups of 20-25 specimens. A checkup was effected every 24 hours (during the photoperiod) and lasted about ten minutes; the dead females were taken out of the dishes and registered every day. Each experiment was repeated two or three times.

The photoperiod and humidity conditions were similar to those created by McMurtry in his comparative research on the Netherlands and Fondi populations.

Naturally, the females used in the experiment were not fed, since previous studies (Ivancich Gambaro, 1990) had demonstrated that females in diapause do not eat, even when food is available.

No cannibalism was noted.

RESULTS AND DISCUSSION

Laboratory experiments. The response of the overwintering females in diapause kept in different RH conditions can be seen in Table 1.

It seems evident that the mortality rate of the females decreases as the humidity increases; this result is the same as the results of researches on eggs made by various authors (McMurtry et al., 1976; De Moraes & McMurtry, 1981; Badie & McMurtry, 1984; Croft et al., 1993). In particular, we can see that at low humidity levels (50% RH) the mortality rate is 100% already in the

Table 1 - Percentage of mortality among overwintering females kept at 50% to 80% RH and 20° - 25 °C.

Temp. °C	RH %	n. ♀♀	Days 2	4	6	8	10		25	40
25	50	80	100	–	–	–	–			
25	60	100	13,0	67,0	10,0	–	–			
25	70	125	11,2	36,7	51,9	–	–			
25	80	50	- - - - -	- - - - -	- - - - -	- - - - -	- - - - >		2	96
20	50	105	20,2	48,4	37,2	–				
20	60	360	1,4	40,3	53,1	4,8				
20	70	60	6,6	16,6	26,6	50,0				
20	80	127	- - - - -	- - - - -	- - - - -	- - - >			2	92

first 48 hours, while at 80% RH some of the females survive up to 25 days and many up to 40 days or more. The difference in mortality is slight, from 60% to 70% RH, and increases considerably from 70% to 80%.

Evident differences can be noted with the variation in temperature, even when this is only 5°C; in fact, with a temperature of 25°C at 70% RH the females die within the fourth to the sixth day, whereas at a temperature of 20°C only a few die within the sixth day and 50% of them survive up to the eighth day. Unlike the results obtained by McMurtry in his research on eggs, here at 70% RH all the females died within eight days. The critical threshold at both 20° and 25° lies between 70% and 80% RH. At 80% RH the mortality rate of the females is limited to 6-7% after 25 days, while 60% of them survive for over 40 days.

RH values in the climate of Verona and Montpellier. Any attempt at making a comparison between the RH conditions in the areas of Verona and Montpellier is rather difficult, though a certain indication can be obtained from the ten-day period averages of the maximum and minimum values for the summer months shown in the diagrams for 1989 and 1990 (Fig. 2). In fact, it is clear that while in Verona (Po Valley) the 10-day period minimum average varies from 40% to 50% but never goes below 40%, the same average at Montpellier ranges from 35% to 40% and in some cases goes as low as 25%. The maximum values in Verona remain constantly between 90% and 95%, while in the Montpellier climate they go from 60% to 80% and rarely exceed 90%. In 1990 the difference between the 10-day period averages in these two areas was less marked.

However a monthly or 10-day period average of RH values in a locality does not express the actual humidity conditions to which the species is subjected. If, for example, in 1990 (a particularly humid year) the 10-day period minimum averages for July in Montpellier are 35%, 32%, and 44% RH, in the individual days the minimum values drop to <40% and often to <30%, so that for 15 days out of 30 the RH is low, while in the Po Valley it never drops below 40%. This leads me to conclude that in the Montpellier area the climate is drier than in the Po Valley in the summer. It must also be pointed out that at Montpellier the temperature is always rather high.

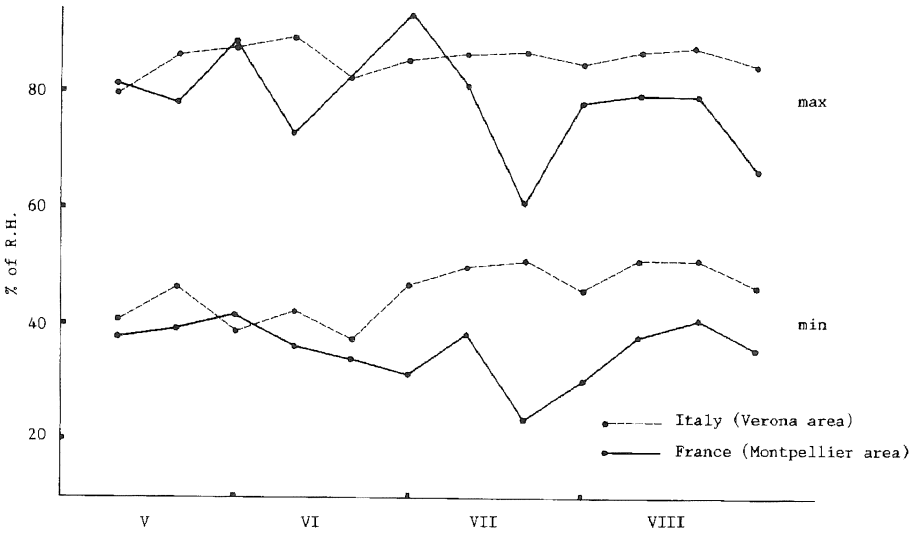

Fig. 2 - Comparison between the average ten-day period RH in the climate of Montpellier and the Po Valley, May-August 1989.

One can put forward the hypothesis that this climate, though limited to the summer months, is unfavourable to the life and development of a species such as *A. andersoni*, whose optimum survival condition is 80% RH.

A. andersoni is typical of the humid coastal regions: Anderson et al. (1958) found it thriving in the coastal areas of the Pacific and not in arid inland valleys; Croft et al. (1990) did not find this species in the dry valleys of Oregon but in the areas near rivers and lakes.

Unfortunately, in Croft et al.'s study the terms «humid» and «dry» are not defined by meteorological data concerning a specific area or season, nor is a comparison made between two different areas.

It is common knowledge that overwintering females find a particularly

favourable environment in the band-traps soaked in water and snow even when the temperature drops as low as –20°C.

Certainly, laboratory findings and observations made on the variations in environmental RH have a purely indicative value because it is no easy task to evaluate the actual humidity to which phytoseiids, and mites in general, are subjected on the lower face of leaves. Ferro et al. (1984) in fact underscored a decreasing humidity gradient from the face of the leaves to the ambient.

In any case, on the basis of both the laboratory results and the studies made on the climate, we can hypothesize that the low humidity level during the summer months in the Montpellier area is unfavourable to the life and growth of *A. andersoni.*

This theory is supported by other cases in literature in which intolerance to low humidity, even for a brief period, has made it impossible for a species to survive. For example, Downing & Moilliet (1974) have noted that *Amblyseius fallacis* (Garman) cannot survive in the apple orchards of British Columbia because of the dry climate in July and August. Hadam et al. (1986) speak of a case of competition between *Typhlodromus occidentalis* Nesbitt and *Typhlodromus pyri* Scheuten caused by the climatic preference of the latter species, which declines from July to September when the climate becomes dry.

Therefore, considering what is known about the effects of humidity on *A. andersoni* and the differences in climatic conditions in Verona and Montpellier, it seems logical to presume that the low humidity in the summer months in the latter area is the cause of the lack of success of *A. andersoni* in its orchards.

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