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POPULATION DYNAMICS OF *MYZUS PERSICAE* (SULZER) ON POTATO IN SICILY *

INTRODUCTION

In 1970-2 a collaborative investigation was carried out in several countries (Brazil, Canada, Italy, Poland, Switzerland, United Kingdom and the U.S.A.) under the auspices of IBP (International Biological Programme) concerning the population dynamics of the peach potato aphid, *Myzus persicae* (Sulzer).

The main aim of the research was to understand the way in which the aphid's numbers were controlled on one of its secondary hosts. Potato was chosen as a suitable crop because of its worldwide distribution and because it is susceptible to several aphid-transmitted virus diseases, of which *M. persicae* is the most active vector.

The methodology to investigate the population dynamics of this aphid was adapted from that of HUGHES (1962, 1963, 1972), originally applied to the cabbage aphid, *Brevicoryne brassicae* (L.). This demographic method was used to estimate the aphid reproductive rate, emigration and natural mortality during the exponential growth of the population and at the beginning of its decline.

METHODS

Our investigations were carried out in 1970 in Lentini (Syracuse, Sicily) in an irrigated field on alluvial soil (fig. 1).

A o.6 hectare plot of the potato variety Majestic was planted on 10 March, with 50 cm between the rows and 40 cm between seed

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tubers within the rows. Meteorological observations (mean temperatures and rainfall) were made daily (table 1) with a thermograph and a rain-gauge, installed in the edge of the experimental plot.

Most plants had emerged by 31 March and the first *M. persisae* were detected in a sample on 9 April, whereafter samples were taken to obtain a record of trends in population growth (table 2). Each sample comprised 24 units, with 6 units taken at random from each

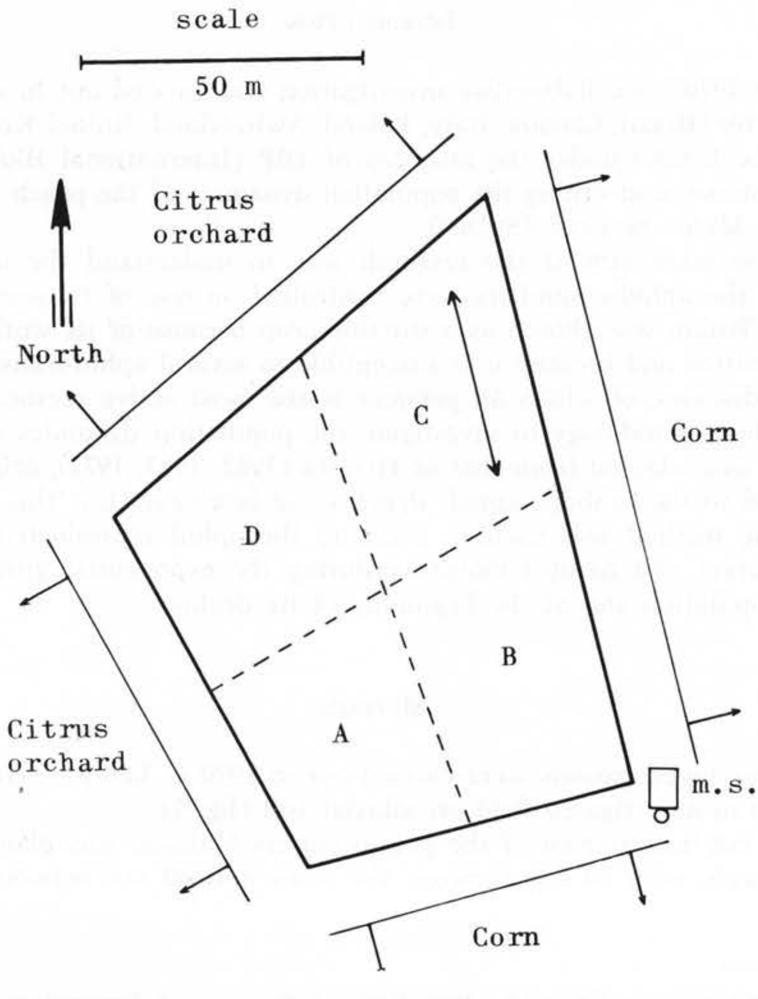

Fig. 1 - Map of the potato plot. - A B C D, subplots; ⟷ direction of rows; m.s., meteorological station.

quarter of the plot. The sample unit was a haulm [1], cut at ground level, placed carefully in a polythene bag and transferred to the laboratory as soon as possible.

All aphids present on each haulm were counted by visual inspection and results expressed as « aphids per haulm » (table 2). *M. persicae* was separated from the other species of aphids; among these *Macrosiphum euphorbiae* (Thomas) and *Aphis gossypii* Glover were commonest during our observations.

The population growth curve (fig. 2) of *M. persicae* was plotted against a « physiological » time-scale, measured in accumulated day-degrees Centigrade. These units were obtained by accumulating, from the day of the beginning of the infestation, the amounts by which the mean daily temperatures exceeded the theoretical temperature threshold for the development of virginoparae, which was estimated at 4° C (Anon, 1970). In this way, the effects of temperature variation were largely eliminated from the growth curve, thus permitting these data to be compared with curves obtained in other investigations. Samples were taken at intervals not more than 100 day-degrees C apart, which corresponded practically to an 8 day interval between samplings at a mean temperature of 16° C (in fact 8 (16 - 4) = 96 day-degrees C).

« Twin-samples » were also taken. These consisted of two samplings taken one « instar-period » apart. An instar-period is the interval of time necessary for the aphid stages of the I, II or III instars to complete their development. These instars have the same developmental times at any given temperature (Foster, 1972). The instar-period is temperature-dependent and can be measured in day-degrees C above the theoretical temperature threshold of growth; between 6° C and 26° C, the instar-period is 31.1 day-degrees C (Anon, 1970).

In the first main sample of each twin-sample, all stages of *M. persicae* were counted and their numbers per haulm calculated. It has been shown (Hughes, 1962) that the numbers of the first three instars should conform to a geometric series if field conditions are sufficiently uniform to allow a stable age-structure to develop. The ratios of numbers of first to second and second to third instars give a multiplication factor, « PIR » (= potential increase rate), which, when

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(1) The haulm is defined as the aerial product of one axillary bud on the seed tuber.
The total aerial product of a seed tuber is defined as a « hill ».

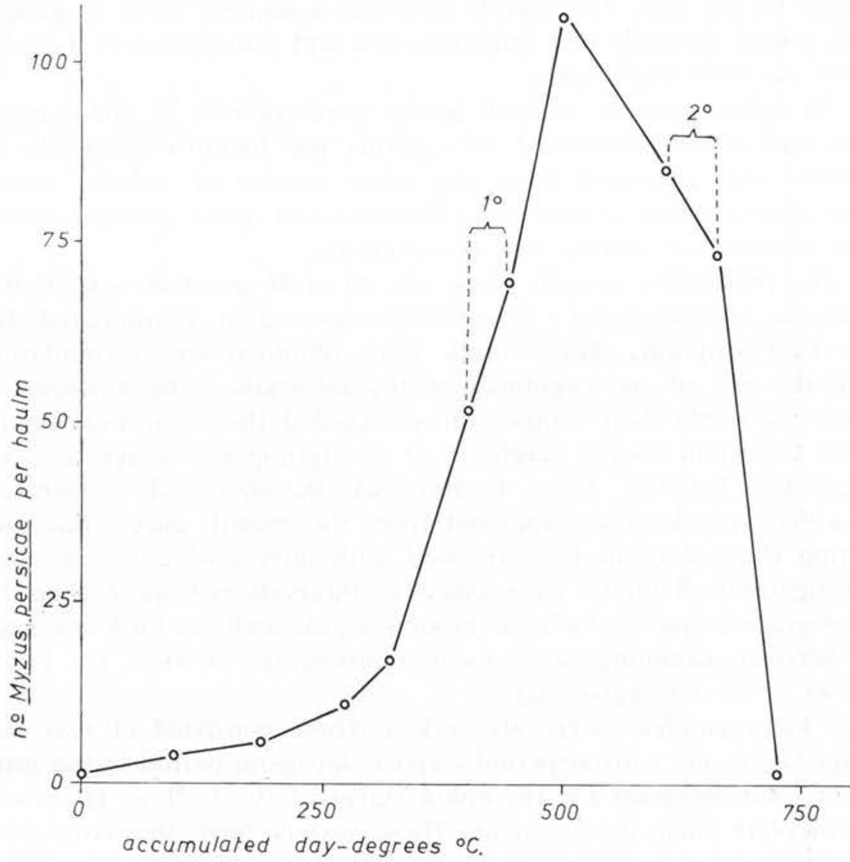

Fig. 2 - Population growth curve of *M. persicae* on a physiological time-scale. - 1° 2°, first and second twin-sample; flowering period between 550-650 day-degrees °C.

multiplied by the first instar numbers, gives the next term up in the geometric series. This term represents the potential number of aphids born in the following instar-period in the absence of natural mortality factors (predation, parasitism and fungus disease).

The best estimate of PIR is obtained from the equation:

$$\text{PIR} = \frac{\text{n° aphids in I + II instars}}{\text{n° aphids in II + III instars}}$$

TABLE 1 - Meteorological data from a potato field at Lentini, Syracuse, Sicily, in 1970, with dates of sampling and cultivation.

Date	Minima of 6°C and below	Mean daily temperature (°C)	Rainfall (mm)	Events
9/4	—	15.6	0	Sample n. 1
10/4	1	11.1	0	
11/4	5	11.2	0	
12/4	—	14.2	0	
13/4	5	11.2	0	
14/4	5	15.0	0	
15/4	—	11.3	2.5	
16/4	3	9.8	0	
17/4	4	11.2	0	
18/4	1	10.1	0	
19/4	1	13.5	0	
20/4	2	13.2	0	Sample n. 2
21/4	2	13.2	0	
22/4	—	14.5	0	
23/4	6	13.9	0	
24/4	6	15.4	0	
25/4	4	13.6	0	
26/4	4	16.2	0	
27/4	6	15.0	0	
28/4	—	14.8	0	
29/4	5	12.2	0	Sample n. 3
30/4	—	13.8	0	
1/5	—	13.2	0	
2/5	1	9.7	0	
3/5	6	10.8	0	
4/5	4	12.7	0	
5/5	0	12.9	0	HOEING
6/5	—	14.5	0	
7/5	—	16.3	0	
8/5	—	16.4	0	Sample n. 4
9/5	—	15.4	0	
10/5	—	16.2	0	
11/5	—	15.6	0	
12/5	—	15.8	0	Sample n. 5
13/5	3	14.9	0	IRRIGATION
14/5	6	15.6	0	
15/5	4	18.0	0	
16/5	—	17.2	0	

Cont. table 1

17/5	6	15.1	0	. . . .
18/5	—	17.1	0	. . . .
19/5	5	16.1	0	1st twin-sample (n. 6)
20/5	—	14.8	0	. . . .
21/5	—	18.7	0	. . . .
22/5	—	18.2	0	1st twin-sample (n. 7)
23/5	—	16.3	0	. . . .
24/5	5	17.1	0	. . . .
25/5	5	15.6	0	. . . .
26/5	5	17.4	0	Sample n. 8
27/5	—	17.3	0	. . . .
28/5	—	18.7	0	. . . .
29/5	—	17.1	0	. . . .
30/5	—	16.6	11.6	. . . .
31/5	—	17.2	0	. . . .
1/6	—	17.2	0	. . . .
2/6	—	18.8	0	. . . .
3/6	—	17.4	0	2nd twin-sample (n. 9)
4/6	—	18.4	0	. . . .
5/6	—	19.4	0	. . . .
6/6	—	20.9	0	2nd twin-sample (n. 10)
7/6	—	20.8	0	. . . .
8/6	—	20.9	0	. . . .
9/6	—	22.3	0	IRRIGATION
10/6	—	21.9	0	Sample n. 11
END OF SAMPLING				

The potential population increment by the end of the instar period is equal to the product of PIR and the number of aphids in istar I, less the number of aphids emigrating. Emigration is calculated from the number of fourth instar alatae at the first main sample:

$$\text{N}^\circ \text{ emigrating alatae} = \text{n}^\circ \text{ IV alatae} \quad \frac{\text{PIR} - 1}{\text{PIR}^{1.5} - 1}$$

where the alate IV instars have a developmental period 1.5 times longer than the duration of either instar I, II or III.

The second main sample of the twin-sample was taken one instar period after the first main sample, and all *M. persicae* were counted without identifying the individual stages. This final estimate of density could then be compared with the expected potential density:

potential density in absence of mortality = (density at 1st main sample) + PIR x (density of instar I at 1st main sample) — (n° of alatae emigrating in instar-period).

Unless mortality factors are negligible, these two densities can never be the same. It is important to note that incidence of some of these factors could be estimated. For this purpose an additional sample was taken at the same time as the main sample. This subsample (comprising a smaller number of haulms, in our case, six haulms instead of 24) was examined in the laboratory soon after sampling, and all predators and mummified or diseased aphids were removed and discarded. The apparently healthy aphids were stored for one instar-period in the laboratory; the subsample was then re-examined carefully and all aphids killed by parasites or fungus disease were recorded (table 3).

TABLE 2 - Population densities of aphids and their predators in a potato field at Lentini, Syracuse, Sicily, in 1970.

Date	Accumulated day-degrees C	Total *Myzus persicae* per haulm	Total aphids per haulm	Predators per haulm: Anthocoridae (nymphs & adults)	Chrysopidae (larvae)	Syrphidae (larvae)	Coccinellidae (larvae & adults)
9/4	0	0.8	3.4	0	0	0	0
20/4	99	3.4	4.2	0	0	0	0
29/4	192	5.9	6.7	0	0	0	0
8/5	277	10.3	13.3	0.16	0.16	0	0.5
12/5	324	16.8	35.2	—	—	—	—
19.5	410	52.0	130.8	0.37	0.25	0.25	1.0
22/5	450	75.5	215.4	—	—	—	—
26/5	500	107.2	345.8	—	—	—	—
3/6	608	85.2	302.8	1.0	1.5	0.5	4.0
6/6	655	74.2	162.0	—	—	—	—
10/6	725	1.0	21.6	—	—	—	—

TABLE 3 - Details of twin-samples of *Myzus persicae* taken in a potato field at Lentini, Syracuse, Sicily, in 1970.

	Twin-sample n. 1		Twin-sample n. 2	
Time and date of 1st main sample	morning, 19 May		morning, 3 June	
Time and date of 2nd main sample	morning, 22 May		morning, 6 June	
Accumulated day-degrees C between samples	38.7		45.0	
N. of haulms sampled on each occasion	24		24	
FIRST MAIN SAMPLE Instar distribution	N. in sample	N. per haulm	N in sample	N. per haulm
Instar I	442	18.4	460	19.2
Instar II	239	10.0	363	15.1
Instar III	175	7.3	396	16.5
Apterous instar IV	99	4.1	115	4.8
Alate instar IV	0	0	308	12.8
Adult apterae	203	8.5	384	16.0
Adult alatae	90	3.7	19	0.8
Total *M. persicae*	1248	52.00	2045	85.20
Potential increase rate (PIR)		1.645		1.084
Potential instar I		30.27		20.79
Alate multiplication factor		—		0.653
Emigrant alatae per haulm		0		8.38
SECOND MAIN SAMPLE				
Total *M. persicae*		1813		1782
Aphids per haulm		75.54		74.25
SUBSAMPLE				
Number of haulms		8		8
Temperature of store-room (°C)		18		18
Period kept (accumulated day-degrees C)		42		42
Number of aphids killed by parasites per haulm		0.25		0.75
Number of aphids killed by fungus disease per haulm		0.37		0.25
MAXIMUM RESIDUAL MORTALITY		6.11		22.35

The results of twin-sampling are best described by means of three histograms, e.g. fig. 3. Histogram *a* represents the mean density of *M. persicae* at the first sampling occasion, with its instar distribution; histogram *b* represents the potential population increase in the absence of emigration and mortality; histogram *c* represents

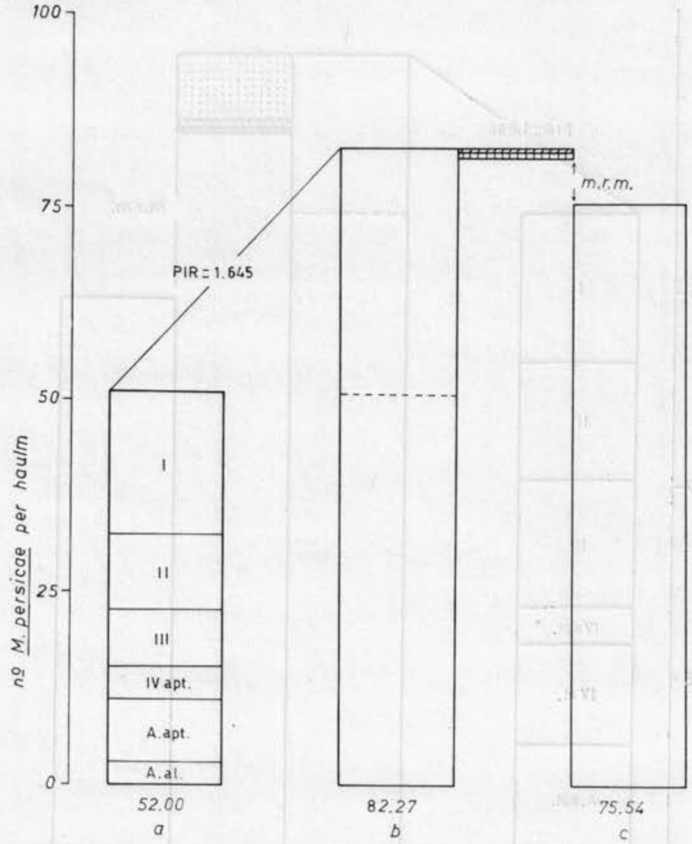

Fig. 3 - First twin-sample data, 19-22/V/1970. - *a*, mean density and instar distribution of *M. persicae* at the first sampling occasion (for the number of individuals in each instar see table 3); *b*, potential population one instar period later; *c*, population density actually observed in the field one instar period later; I II III, first, second and third instars; IV apt., fourth apterous instar; A.apt. A.al., apterous and alate adults; |//////|, parasitism; |||||||||, fungus disease; m.r.m., maximum residual mortality.

the population density actually observed in the field after one instar-period. The difference between *b* and *c* shows the losses incurred by the field population. Emigration, parasitism and fungus disease losses can be calculated and subtracted from the top of histogram *b*, leaving « maximum residual mortality », which we ascribed to predation.

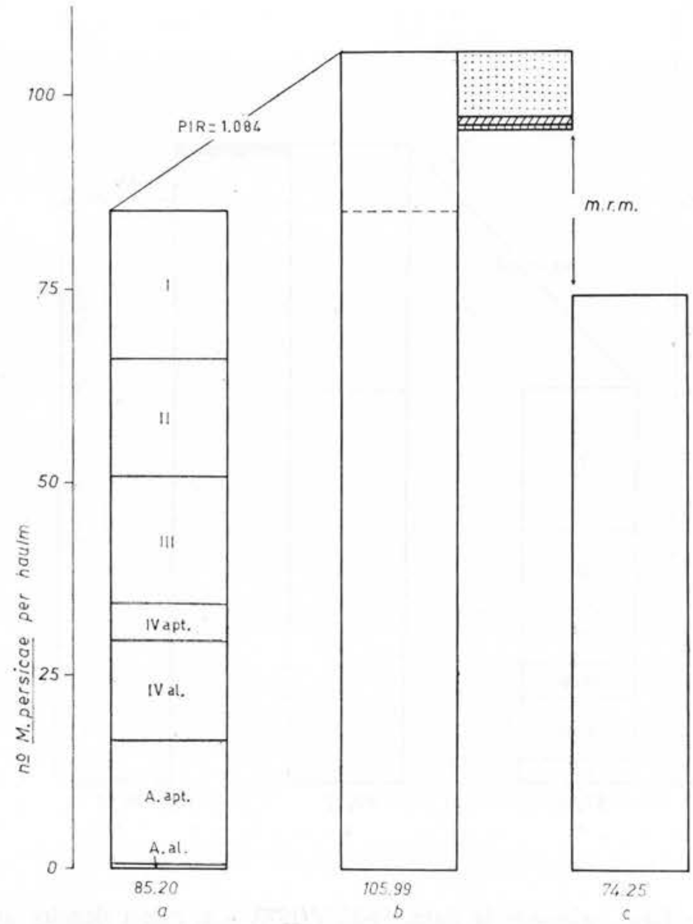

Fig. 4 - Second twin-sample data, 3-6/VI/1970. - IV al., fourth alate instar; [dotted box], emigration. (For other symbols see fig. 3.)

Results and discussion

The population growth curve (fig. 2) showed that the multiplication rate was slow at the beginning of the infestation but increased quickly between 300 and 500 day-degrees C. The decline occurred not long after the flowering of potato. The *M .persicae* infestation lasted 2 months on this crop, equivalent to 725 day-degrees C.

The twin-samples, taken on 19-22 May 1970 (table 3, fig. 3) and 3 - 6 June 1970 (table 3, fig. 4), showed a high value of PIR (1.645) during the rapid increase of the population, equivalent to a birth rate per reproducing aptera (Hughes, 1963) of 3.6 nymphs per instar-period, but a low value of PIR (1.084, equivalent to 0.71 nymphs per reproducing aptera per instar-period) in the decline phase. No emigrants were being produced at the time of the first twin sample, but 7.9% of the potential population emigrated in the twin-sample taken during the decline phase, and accounted for 26.4% of the total loss.

Few aphids were killed by parasites or by fungus disease in either twin-sample. Predators (*Coccinellidae, Chrysopidae, Syrphidae* and *Anthocoridae*) became increasingly common during the season (table 2). Their effectiveness also increased: from 7% of the potential aphid population killed in the first twin -sample to 21% in the second twin-sample. Combined with the decline in aphid reproductive rate (which may have been due either to a change in host -plant quality or to the effects of crowding), their activity was decisive in bringing about the crash of the aphid population.

SUMMARY

The population dynamics of *Myzus persicae* (Sulzer) on potato were studied in Sicily in 1970.

Rates of aphid reproduction, emigration and mortality were estimated using Hughes' demographic method. An aphid population growth curve was plotted on a physiological time-scale.

The infestation lasted two months; population growth was slow initially, became very rapid and then declined sharply after flowering. Aphid reproductive rate was high in the exponential phase of growth but much lower shortly after decline; this was coupled with increased emigration and predation, bringing about a population crash. Parasites and fungus disease were of little importance in controlling the population.

RIASSUNTO

DINAMICA DELLE POPOLAZIONI DI *MYZUS PERSICAE* (SULZER) INFESTANTE LA PATATA IN SICILIA

Nell'ambito di un piano di ricerca promosso dall'IBP, è stata svolta (negli anni 1970-72) un'indagine collegiale in vari Paesi del mondo al fine di avere una panoramica mondiale sulla dinamica delle popolazioni di *M. persicae* (Sulzer) vivente sulla Patata.

Il motivo principale dello studio è stato quello di ottenere una migliore conoscenza del comportamento epidemiologico dell'afide su una coltura, quale quella della Patata, di notevole diffusione e soggetta a svariate malattie da virus trasmesse a mezzo di afidi, tra i quali il *M. persicae* è certo uno dei principali vettori.

Per l'indagine sulla dinamica delle popolazioni dell'afide in oggetto si è adottato il metodo messo a punto da HUGHES (1962 e 1963) studiando la dinamica delle popolazioni di *Brevicoryne brassicae* (L.). Il lavoro è consistito nell'effettuare una serie di conteggi successivi degli esemplari di *M. persicae* presenti su un numero standard di piante prese a caso dal campo (con sistema randomizzato) a partire dall'inizio dell'infestazione del fitofago, al fine di tracciare una curva di crescita della popolazione, riportando su un sistema di assi cartesiani i valori numerici della popolazione conteggiata e riferiti ad una scala « fisiologica di tempo ». Le unità di misura (« gradi-giorni ») di quest'ultima sono ricavate dal prodotto tra il numero dei giorni intercorsi fra un campionamento e l'altro e la temperatura media del periodo considerato, diminuita di 4° C (soglia minima di sviluppo dell'afide).

Oltre ai conteggi ordinari di cui sopra, sono stati eseguiti dei prelevamenti particolari, detti « campionamenti-doppi », che constano di due rilievi successivi intervallati di uno « stadio-periodo » dell'afide. Quest'ultimi rilievi consentono, conteggiando i diversi stadi preimmaginali dell'insetto presenti in campo, di poter calcolare l'incremento potenziale che la popolazione dell'afide raggiungerebbe in assenza di fattori naturali di mortalità nell'intervallo di uno stadio-periodo. Questo calcolo si effettua moltiplicando il numero di individui di 1ª età per il coefficiente PIR (= potential increase rate), il quale corrisponde al quoziente tra la somma delle neanidi di 1ª e 2ª età e la somma delle neanidi di 2ª e 3ª età. La differenza tra questo valore teorico d'incremento potenziale della popolazione e l'incremento effettivamente registrato in campo alla fine dello stadio-periodo, fornisce l'entità di riduzione subita dalla popolazione per effetto degli accennati fattori naturali di mortalità (parassiti, funghi e predatori, che hanno operato in campo) e della migrazione. Le perdite subite dalla popolazione in campo per effetto dell'attività dei predatori (mortalità massima residua) si desumono sottraendo al valore teorico dell'incremento potenziale della popolazione le perdite dovute al parassitismo (entomofagi parassiti e funghi entomopatogeni) e alla migrazione, i cui valori possono essere direttamente calcolati con i procedimenti riportati più estensivamente nel testo.

Dalla curva di dinamica della popolazione, ottenuta dai nostri rilievi effettuati in Sicilia nel 1970, si deduce che il valore numerico della stessa si intensifica repentinamente a partire da 300 gradi-giorni e inizia a decrescere rapidamente dopo 500 gradi-giorni. Il giorno-grado 0 (zero) corrisponde all'inizio dell'infestazione dell'afide in campo; i giorni-gradi che seguono sono ottenuti come sopra accennato.

I prelievi dei due « campionamenti-doppi », uno effettuato durante la fase di massimo incremento della popolazione e l'altro durante la fase di declino della stessa, mettono in evidenza che nella fase di intensa attività riproduttiva dell'afide i fattori di mortalità risultano di limitata entità, mentre nella successiva fase di declino della popolazione l'attività svolta dai fattori di mortalità risulta sensibilmente più accentuata. Inoltre la mortalità dell'afide dovuta a parassitismo è risultata notevolmente inferiore a quella causata dall'azione limitante dei predatori.

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