Hb

Union Internationale des Sciences Biologiques

ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE ET INTEGREE CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES

SECTION REGIONALE OUEST PALEARCTIQUE

ISBN 92 9067 038 X

WORKING GROUP "INTEGRATED CONTROL IN CEREAL CROPS"

GROUPE DE TRAVAIL "LUTTE INTEGREE EN CEREALES"

PROCEEDINGS OF THE MEETING AT GÖTTINGEN (F.R.G.)
21 - 22 MARCH 1990

EDITED BY
EDITE PAR
C.A. DEDRYVER

IOBC / WPRS BULLETIN
BULLETIN OILB / SROP

1991 / XIV / 4

International Union of Biological Sciences

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL AND INTEGRATED CONTROL OF NOXIOUS ANIMALS AND PLANTS

WEST PALAEARCTIC REGIONAL SECTION

WORKING GROUP "INTEGRATED CONTROL IN CEREAL CROPS"

PROCEEDINGS OF THE MEETING AT GÖTTINGEN (F.R.G.)
FROM 21 - 22 MARCH 1990

GROUPE DE TRAVAIL "LUTTE INTEGREE EN CEREALES"

COMPTE - RENDU DE LA REUNION A GÖTTINGEN (R.F.A.)
DE 21 - 22 MARS 1990

EDITED BY
EDITE PAR
C.A.DEDRYVER

IOBC / WPRS BULLETIN
BULLETIN OILB / SROP
1991 / XIV / 4

Union Internationale des Sciences Biologiques
ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE ET INTEGREE CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES
SECTION REGIONALE OUEST PALEARCTIQUE
International Union of Biological Sciences
INTERNATIONAL ORGANIZATION FOR BIOLOGICAL AND INTEGRATED CONTROL OF NOXIOUS ANIMALS AND PLANTS
WEST PALAEARCTIC REGIONAL SECTION

IS YOUR ORGANISATION ALREADY MEMBER OF IOBC/WPRS?

If you benefit from the activities of IOBC/WPRS, then please convince your institute or organisation to become a MEMBER!!

As a non-profit organisation for the promotion of biological and integrated control in Europe, IOBC/WPRS urgently needs the contribution of its MEMBERS in order to be able to support and stimulate the important activities of the Working and Study Groups.

If you are interested, then please complete the following form and send it to: dr. S.H. POITOUT,

Secretary General IOBC/WPRS
INRA Station de Zoologie et d'Apidologie
Domaine Saint Paul, B.P. 91
84143 Montfavet Cedex, France
Telephone +3390316170
Telefax +3390316298

I would like to receive information about:

0 Institutional Membership (for non-profit organisations)

0 Supporting Membership (for example for commercial organisations)

Name:..................................

Address:..............................

Pour la promotion des systèmes de protection intégrée
For the promotion of integrated protection systems

VOTRE ORGANISATION EST ELLE DEJA MEMBRE DE L'OILB/SROP ?

Si vous bénéficiez des activités de l'OILB/SROP, alors attachez vous s'il vous plait à convaincre votre Institut ou Organisation d'adhérer à l'OILB/SROP, devenant ainsi un de ses MEMBRES!!

L'OILB/SROP est une Organisation à buts non lucratifs pour la promotion de la lutte biologique et intégrée, elle a donc un besoin impérieux de la contribution de ses membres, afin de pouvoir soutenir et stimuler les importantes activités de ses Groupes de travail et d'études.

Si vous êtes intéressé, complètez s'il vous plait le formulaire suivant et envoyez le au: dr. S.H. POITOUT,

Secrétaire général de l'OILB/SROP
INRA Station de recherches de Zoologie et d'Apidologie
Domaine Saint Paul, B.P. 91
84143 Montfavet Cedex, France
Téléphone +3390316170
Téléfax +3390316298

Je souhaiterai recevoir une information concernant:

0 Membre institutionnel (pour les instituts à buts non lucratifs)

0 Membre bienfaiteur (par exemple pour les Organismes commerciaux)

Nom: ....

Adresse: ....

AVANT PROPOS

La réunion bisannuelle de notre groupe de travail a été organisée par notre collègue Michael Poehling et s'est tenue les 21 et 22 mars 1990 à l'Institut de pathologie végétale et de protection des plantes de l'Université de Göttingen (RFA). Elle nous a donné l'occasion de célébrer avant la lettre la réunification de l'Allemagne, puisque 5 collègues de la section de protection des plantes de l'Université de Martin Luther de Halle (à l'époque en RDA) ont activement participé à cette réunion et ont demandé à faire partie du groupe.

La réunion a donné lieu à 17 communications portant sur la biologie et la dynamique des populations de pucerons des céréales et les méthodes de prévision des pullulations, l'épidémiologie de la jaunisse nanisante de l'orge et la prévision des épidémies, l'action des hyménoptères parasitoides et hyperparasitoides et le rôle des prédateurs polyphages, particulièrement en relation avec les traitements insecticides. Enfin une communication traite du puceron *Diuraphis noxia,* nouveau ravageur introduit en Amérique du Nord, et de l'inventaire de ses ennemis naturels dans ses zones d'habitat traditionnelles et une autre résume les recherches entreprises en France sur la Pyrale du maïs.

Au cours de la discussion qui a suivi, trois sujets de collaboration ont été proposés pour les prochaines années :

Le premier projet, proposé par Th. Basedow consiste à renforcer les liens entre les quelques collègues spécialisés dans l'étude des prédateurs polyphages autour d'une expérimentation multisite utilisant des méthodes standard.

Le second projet a été proposé par M. Poehling et C.A. Dedryver, autour de l'épidémiologie de la jaunisse nanisante de l'orge ; il consiste à comparer la biologie des vecteurs (particulièrement les modes d'hivernation) et les différentes souches de virus présentes, selon un arc de cercle allant du Nord de l'Espagne (Lerida) au Nord de l'Allemagne (Göttingen) en passant par la France (Rennes) et l'Ouest de l'Allemagne (Stuttgart). Les conclusions de ce projet seront débattues au cours de la prochaine réunion où des virologues seront invités.

Le troisième projet a été proposé par C.A. Dedryver, il consiste à créer une banque de données sur les fluctuations de populations de pucerons des céréales, au départ dans trois pays, France, Allemagne et Grande Bretagne. Elle serait constituée de résultats de comptages et d'observations et serait à la disposition de tous avec l'accord des parties intéressées. Cette banque de données, qui dans certains cas rassemblerait plus de 10 années d'observations, permettrait des comparaisons inter-régionales du plus grand intérêt.

L'ensemble des participants a, pour terminer, adressé ses remerciements chaleureux à M. Poehling pour l'excellente organisation matérielle et scientifique de la réunion.

L'animateur
C.A. DEDRYVER

FOREWORD

The bisannual meeting of the working group was organised by our colleague Michael Poehling and was held on 21st and 22nd March 1990 at Göttingen (FRG), Institut of Plant pathology and Plant protection of the University. This meeting gave us the opportunity to celebrate in advance the reunification of Germany, because five colleagues of the plant protection service of the University Martin Luther of Halle (previously in GDR) attended it and asked to belong to our group. Twenty six participants belonging to 7 countries attended the meeting, and 17 papers were presented. The main topics were :

. biology, population dynamics of cereal aphids and forecasting methods
. epidemiology of BYDV and epidemics forecast
. role of hymenopterous parasitoids and hyperparasitoids
. role of epigeal predators, specially in relation with insecticides sprays.

Another communication concerned *Diuraphis noxia*, a newly introduced pest in America and the inventory of its natural enemies in the old world and finally, a last paper summarised the researches in France on the european corn borer.

From the discussion, 3 new projects were planned for the following years.

. The first project was proposed by Th. Basedow and consisted to strenghten links between colleagues working on epigeal predators with a common experiment using standard methods.

. The second project was proposed by M. Poehling and C.A. Dedryver on BYDV epidemiology. Its aim was a comparison of vectors biology (specially overwintering) and virus strains on different locations : North of Spain (Lerida), France (Rennes), Western and Northern Germany (Stuttgart and Göttingen). Virologists will be invited at the next meeting.

. The third project was proposed by C.A. Dedryver and consisted to create a data bank on cereal aphids (First in France, Germany and U.K.), using the counting data collected in the 3 countries. This data bank will concern in some cases more than 10 years of observations and will allow interesting interregional comparisons.

The advances in these projects will be discussed at the next meeting. Finally the whole participants thanked M. Poehling and his staff for the excellent material and scientific organisation of the meeting.

The convenor
C.A. DEDRYVER

LISTE DES PARTICIPANTS/LIST OF THE PARTICIPANTS

Thies BASEDOW	Institut für Phytopathologie und angewandte Zoologie, Universität Gießen, Ludwigstr. 23, 6300 Gießen, BRD.
Christian BORGEMEISTER	Institut für Pflanzenpathologie und Pflanzenschutz, Universität Göttingen, Grisebachstr. 6, 3400 Göttingen, BRD.
Petra CHRISTIANSEN-WENIGER	Institut für Phytopathologie, Universität Kiel, Olshausenstr. 40-60, 2300 Kiel, BRD.
Jordi COMAS	Institut de Recera i Technologia Agroalimentaries, Universitat Politecnica de Catalunya, Centre R+D de Lleida, Alcade Rovira Roure. 177, 25006 Lleida, ESPANA
Roger DE CLERCQ	Rijksstation voor Nematologie en Entomologie, Universiteit Gent, Burg. Van Gansberghelaan 96, B-9220 Merelbeke, BELGIE - BELGIQUE.
Charles DEDRYVER	INRA Le Rheu, Laboratoire de Recherches de la Chaire de Zoologie, Domaine de la Motte au Vicomte, B.P. 29, 35650 Le Rheu. France.
Axel DINTER	Institut für Pflanzenpathologie und Pflanzenschutz, Universität Göttingen, Grisebachstr. 6, 3400 Göttingen BRD.
Ulf GRÖGER	Institut für Phytomedizin, Universität Hohenheim, Otto-Sander-Str. 5, 7000 Stuttgart 70, BRD.
Francis GRUBER	European Parasite Laboratory, rue de la Masse 13-17, 78910 Orgerus-Behoust, France.
Helmut HAARDT	Institut für Pathologie, Universität Kiel, Olshausenstr. 40-60, 2300 Kiel, BRD.
Udo HEIMBACH	BBA, Messeweg 11/12, 3300 Braunschweig, BRD.
Juha HELENIUS	Department of Agricultural and Forest Zoology, University of Helsinki, SF00710 Helsinki, Finland.
Falco HOLZ	Sektion Pflanzenproduktion, Martin-Luther-Universität Halle-Wittenberg, Ludwig-Wucherer-Str. 2. Postamt 1, 0-4010 HALLE (Saale), BRD.
Martin KREUTER	Sektion Pflanzenproduktion, Martin-Luther-Universität Halle-Wittenberg, Ludwig-Wucherer-Str. 2. Postamt 1, 0-4010 HALLE (Saale), BRD.

Guy LATTEUR	Station de Zoologie Appliquée, Chemin de Liroux 8, B-5800 Gembloux, BELGIQUE-BELGIE
Gerhard LAUENSTEIN	Landwirtschaftskammer Weser-Ems, Pflanzenschutzamt, Postfach 2549, 2900 Oldenburg, BRD.
Françoise LECLERCQ-LE QUILLEC	INRA Le Rheu, Laboratoire de Recherches de la Chaire de Zoologie, Domaine de la Motte au Vicomte, B.P. 29, 35650 Le Rheu. France.
Marita LÜBKE	Sektion Pflanzenproduktion, Martin-Luther-Universität Halle-Wittenberg, Ludwig-Wucherer-Str. 2. Postamt 1, 0-4010 HALLE (Saale), BRD.
Hans-Michael POEHLING	Institut für Pflanzenpathologie und Pflanzenschutz, Universität Göttingen, Grisebachstr. 6, 3400 Göttingen, BRD.
Xavier PONS	Institut de Recerca i Technologia, Agroalimentaries, Universitat Politecnica de Catalunya, Centre R+D de Lleida, Alcade Rovira Roure. 177, 25006 Lleida, ESPANA.
Jean-Christophe SIMON	INRA Le Rheu, Laboratoire de Recherches de la Chaire de Zoologie, Domaine de la Motte au Vicomte, B.P. 29, 35650 Le Rheu. France.
Nutcharee SIRI	Institut für Phytopathologie, Universität Kiel, Olshausenstr. 40-60, 2300 Kiel, BRD.
Keith SUNDERLAND	Institute of Horticultural Research, Worthington Road Littlehampton, West Sussex BN17 6LP, UK.
Brigitte TENHUMBERBG	Institut für Pflanzenpathologie und Pflanzenschutz, Universität Göttingen, Grisebachstr. 6, 3400 Göttingen, BRD.
Bernd ULBER	Institut für Pflanzenpathologie und Pflanzenschutz, Universität Göttingen, Grisebachstr. 6, 3400 Göttingen, BRD.
Christa VOLKMAR	Sektion Pflanzenproduktion, Martin-Luther-Universität Halle-Wittenberg, Ludwig-Wucherer-Str. 2. Postamt 1, 0-4010 HALLE (Saale), BRD.
Theo WETZEL	Sektion Pflanzenproduktion, Martin-Luther-Universität Halle-Wittenberg, Ludwig-Wucherer-Str. 2. Postamt 1, 0-4010 HALLE (Saale), BRD.

SOMMAIRE/CONTENTS

DIFFERENT PATTERN OF CEREAL APHID POPULATION DYNAMICS IN NORTHERN (HANNOVER-GÖTTINGEN) AND SOUTHERN AREAS OF WEST GERMANY

H.M. Poehling[1], B. Tenhumberg[1] und U. Groeger[2]
[1] Institute of Plant Pathology, University of Göttingen, Göttingen, FRG
[2] Institute of Phytomedicine, University of Hohenheim, Suttgart-Hohenheim, FRG

Summary

Studies in different regions of Western Germany (Hannover, Göttingen, Stuttgart-Hohenheim) showed that the variability in cereal aphid population pattern decreased when a regional differentiation was performed. Therefore a more regional forecast of cereal aphids is necessary to improve the current West German threshold model. A multiple regression analysis according to Entwistle and Dixon (1986) seems to be a promising approach to predict peak densities with a higher accuracy.
One reason for the different development of cereal aphids in Hannover and Stuttgart seems to be the variable coincidence between aphids and syrphids. Possible reasons for that are discussed.

1.1 Introduction

Today the control of cereal aphids in winter wheat in Western Germany is based on estimates of aphid density during ear emergence (EC 55/59) and the end of flowering (EC 69). If the critical value of 1 aphid /ear or flag leaf is exceeded, the farmers are recommended to spray (Basedow et al., 1989). This means that the evaluation of aphid populations is often based on a single estimate of numbers of aphid per ear and flag leaf (or the percentage of infested tillers). The current threshold is derived from a series of investigations during 1980 - 1983, in which effects of aphid elimination by spraying with pirimicarb at different growth stages and different aphid densities on yield were investigated. Underlying is the assumption that if this critical aphid density is reached or exceeded - even at the end of anthesis - the pest will still increase with a maximum rate reaching peak densities above an injury level between EC 71 and 75.

By using this very simple model unnecessary applications of insecticides could be avoided on an average of nearly 50 % compared with prophylactic treatments. On the other hand still large areas are still treated although in many cases aphids never reach damaging densities.

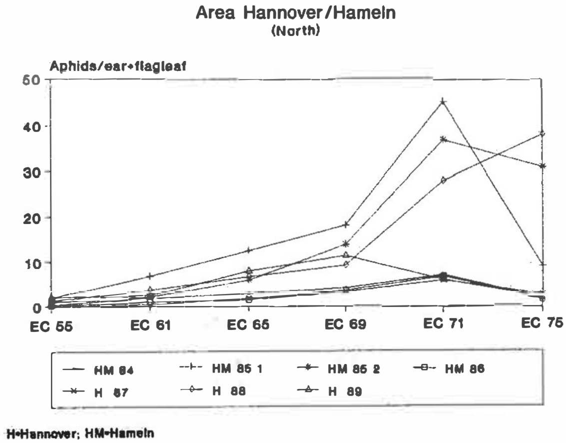


Fig.1 Population pattern of cereal aphids from selected fields in Hannover/Hameln bettween 1984 and 1989.

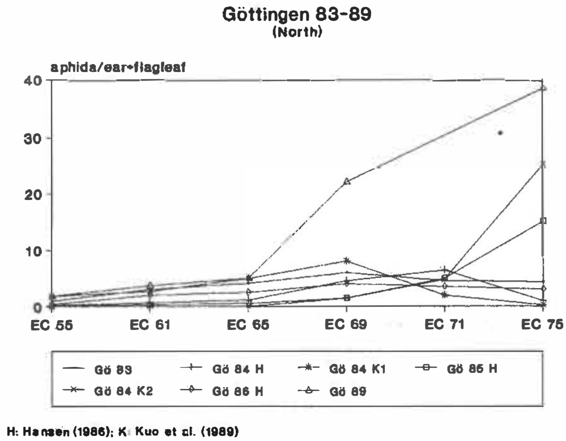


Fig. 2 Population pattern of cereal aphids in Göttingen between 1983 and 1989.

In Göttingen beside all variations two more general types of population patterns could be observed:

1. Relative high densities at booting or early anthesis were followed by a low increase. Peak densities were reached at EC 69 or even before.

In order to improve the accuracy of this model we made an attempt to evaluate the variability of cereal aphid population pattern between different years and different regions in Germany. In addition we checked the multiple regression system of Entwistle and Dixon (1986) for its usefulness to improve the forecasting of aphid peak densities. Differences in regional pattern are discussed by especially considering the role of syrphid larvae as one key factor of the cereal aphid population dynamics.

1.2 Results and discussion

Fields

Data were evaluated from different regions:

- Stuttgart-Hohenheim:

This area does not belong to the outbreak areas in Germany and is characterized by a rather high heterogenity of the landscape with small fields predominating (Schier, 1988; Ohnesorge and Schier, 1989).

- Hannover/Hameln:

In this typical outbreak region intensive wheat production is performed on larger fields, there are often only small areas covered with pastures or hedges surrounding the fields.

- Göttingen:

The Göttingen area is quite similar to Hannover (100 km to the south), but particularly the small experimental fields in which the trials were conducted showed more of the features described above for Stuttgart-Hohenheim.

Cereal aphid pattern

The typical pattern of cereal aphid population dynamics in the regions of Hannover and Göttingen are shown in Fig. 1 and Fig. 2. In Hannover the population curves show a high degree of similarity and consistency in relation to wheat growth stages (Poehling, 1988). Except for 1989 in all cases the peak densities were reached between EC 69 and EC 75. Averaging the density values at different growth stages resulted in a "mean" pattern shown in Fig.4.

In most years Sitobion avenae was the predominant species although Metopolophium dirhodum always immigrated earlier except from those years with anholocylic hibernation of S. avenae. Large differences however occurred between different years if peak densities were concerned. The pattern of 1985, 1988 and 1989 fitted very well to the threshold model of Basedow et al., (1989) but in 1984, 86 and 87 aphid peak densities were far below 10 aphids/ear and flag leaf. According to the threshold model in the latter case insecticides had to be sprayed too.

2. Low densities at the beginning of flowering were followed by a late, rapid and intensive population growth at the end of anthesis (Kuo et al., 1989).

In consequence the "mean" growth curve for this region (Fig. 4) is very different with the one of the Hannover area.

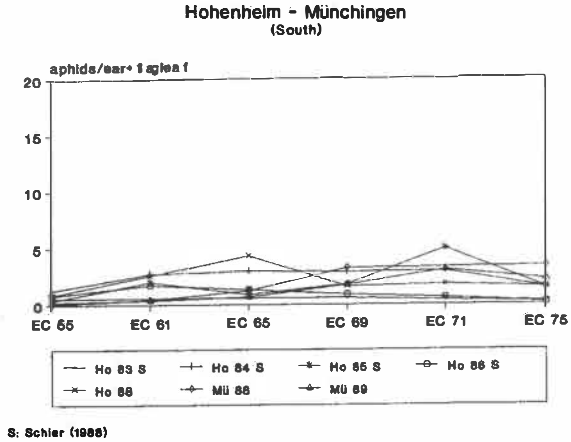


Fig. 3 Population patttern of cereal aphids from selected fields in Hohenheim from 1984 - 1989.

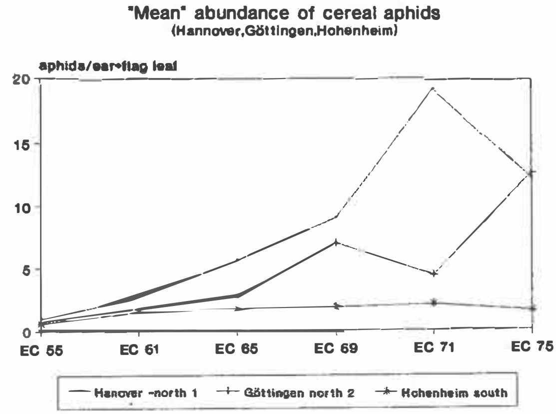


Fig. 4 "Mean" population pattern of cereal aphids from three different regions in Western Germany

The development of ceral aphid populations in Hohenheim exhibited larger differences in relation to the pattern of the two other localities (Fig. 3).

In most cases real gradations could never be observed although aphid densities were rather high at booting and early anthesis. The decline of aphid populations often started rather early, sometimes already at mid anthesis (Schier, 1988). In all years M. dirhodum was the dominating species. S. avenae appeared late and reached only small densities although the physiological conditions of the host-plant were convenient for this species too.

Multiple regression analysis

An interesting approach to the calculation of the peak density of Sitobion avenae with relative simple means using a multiple regression analysis was described by Entwistle and Dixon (1986). A similar calculation was performed for the here described population pattern, by using whole aphid numbers (S. avenae + M. dirhodum) on ears and flag leafs. Peak densities were correlated with either the aphid densities at different times (EC 55-69) or the rate of increase between growth stages or both (multiple regression).

For the Hannover area a close relation existed between aphid densities at distinct times during flowering and peak densities (Table 1, Fig.5). Corresponding to the results of Entwistle and Dixon (1986) the significance rose with progressing growth stages. The rate of increase showed a much smaller correlation (Table 1, Fig 5). An explanation for this phenomenon could be that the parameter "density" explained most of the variation of peak density in this region and that only minor effects of other regulation factors - like natural enemies - influenced aphid development during this period. Further more the rate of increase may be strongly influenced by extended periods of immigration which was not considered in these studies.

A multiple correlation using both parameters improved the accuracy of the prediction, which may be indicated here by the high r-squared values (Table 1) and the 1:1 line of predicted versus observed peak densities (Fig. 5). Considering the differences between observed and predicted values the accuracy of the model seems to be unsatisfactory. On the other hand the model provided a sufficient accuracy to select cases with critical densities. That means an exceeding of relevant infestation levels between 5 and 10 aphids per plant (Table 2).

Table 1 Regression analysis (Hannover - north)

A:
Relation of mean peak number of aphids * (y) to the mean number of aphids (x) at different growth stages (EC). (Hannover - north)

EC 55	$\ln y = 2.833 + 0.471 \ln x$	$r = 0.53$	$r^2 = 28.15$ %
EC 61	$\ln y = 2.000 + 0.799 \ln x$	$r = 0.83$	$r^2 = 66.16$ %
EC 65	$\ln y = 1.087 + 0.415 \ln x$	$r = 0.82$	$r^2 = 68.13$ %
EC 69	$\ln y = 0.246 + 1.152 \ln x$	$r = 0.89$	$r^2 = 80.29$ %

B:
Relation of mean peak number of aphids * (y) to the rate of increase in mean number of aphids/ day (x)

r EC 55-61	$\ln y = 2.519 + 0.416 \ln x$	$r=0.043$	$r^2= 0.19$ %
r EC 61-65	$\ln y = 1.758 + 3.614 \ln x$	$r=0.350$	$r^2=12.17$ %
r EC 65-69	$\ln y = 1.756 + 5.645 \ln x$	$r=0.411$	$r^2=16.94$ %
r EC 55-65	$\ln y = 1.697 + 3.830 \ln x$	$r=0.307$	$r^2= 9.45$ %
r EC 61-69	$\ln y = 1.723 + 4.507 \ln x$	$r=0.367$	$r^2=13.50$ %

C:
Multiple regression of the mean peak number of aphids (y) and the mean number of aphids (x_1) and the rate of increase (x_2)

EC 69 / r EC 65-69	$\ln y = -0.277 + 1.103 \ln x_1 + 4.117 x_2$ $r^2 = 86.04$ %
EC 69 / r EC 61-69	$\ln y = -0.328 + 1.139 \ln x_1 + 3.301 x_2$ $r^2 = 83.84$ %
EC 65 / r EC 61-65	$\ln y = 0.531 + 0.962 \ln x_1 + 2.236 x_2$ $r^2 = 65.06$ %
EC 65 / r EC 55-65	$\ln y = 0.138 + 0.967 \ln x_1 + 3.837 x_2$ $r^2 = 70.85$ %
EC 61 / r EC 55-61	$\ln y = 1.514 + 0.829 \ln x_1 + 1.952 x_2$ $r^2 = 61.50$ %

Also for the Göttingen area relatively precise predictions were obtained by the multiple regression analysis, but concerning the too low number of evaluated fields (i.e. 7) the results have to be regarded as prelimenary until now. It has still to be mentioned that a multiple regression for both areas (Hannover + Göttingen) - although in this case 20 sites were used for the calculation - decreased the accuracy of the predictions (r-squared values in Table 3).

This is an additional indication for the regional specification of the population dynamics of cereal aphids and stresses the need for more differentiated regional forecasting systems.

In general it could be summarized that the variability in cereal aphid population pattern decreased when a regional differentiation was performed. Not only between southern and northern areas very different types regularly occur but also in areas relative close to each other signs of more or less regularly recurrend pattern can be noticed. Therefore more regional forecast of cereal aphids is necessary to improve the current West German threshold model. The multiple regression analysis seems to be a promising approach to an achievement of a higher accuracy for the prediction of peak densities but this assertion has to be confirmed in future by using more data to calculate the representative regression equations. Last but not least a validation with independend data has to be performed.

Table 2

Comparison of observed and predicted values for peak density of aphids per ear and flag leaf. Multiple regression - EC 69 /r EC 61 - 69) (Hannover - North 1)

Field	observed	predicted	relative difference (observed = 100 %)
1 (1984)	6.8	5.9	12.70 %
2 (1985)	44.7	42.4	5.06 %
3 (1985)	36.3	52.9	45.96 %
4 (1985)	14.0	12.9	7.60 %
5 (1985)	36.3	36.4	0.02 %
6 (1986)	6.5	5.2	20.00 %
7 (1986)	2.7	4.2	54.76 %
8 (1987)	5.7	6.7	17.50 %
9 (1988)	37.5	17.8	53.39 %
10 (1989)	11.4	14.8	29.74 %

Table 3

Comparison of r^2- values from multiple regression analysis
(Ha = Hannover; Gő = Gōttingen

x_1	x_2	Ha	Gō	Ha + Gō
69	65 - 69	86.48	41.52	71.47
69	61 - 69	83.44	96.42	76.55
65	61 - 65	65.06	62.80	53.74
65	55 - 65	70.85	47.95	57.73
61	55 - 61	61.50	57.57	59.86

x_1 = Aphids / ear + flaf leaf
x_2 = rate of increase

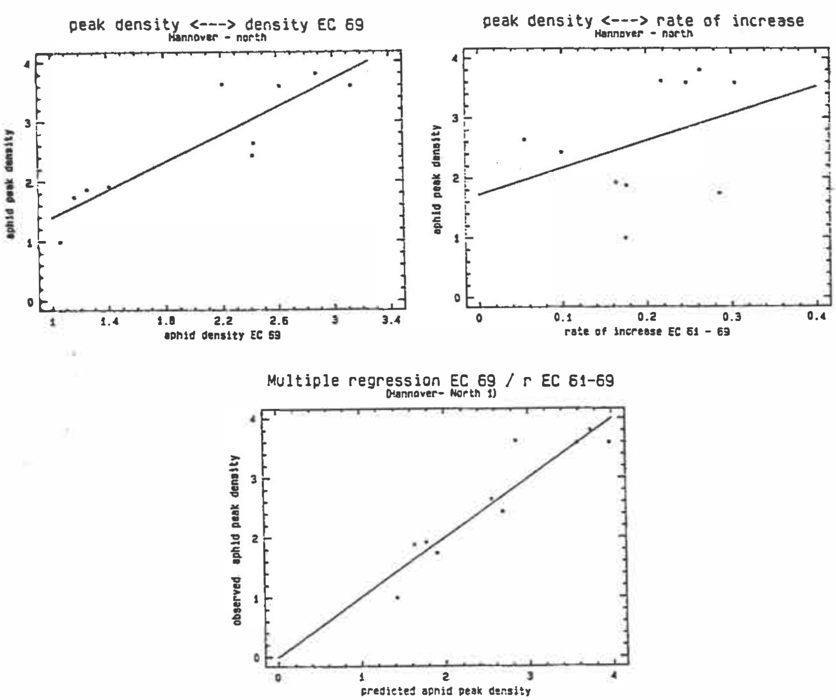


Fig. 5 Regression analysis - Single linear regression (A and B) and multiple linear regression 1:1 line (C)

Effects of syrphid larvae

Irrespective of the possibility to use the regression analysis it is important to analyse the reasons for the very different population pattern of cereal aphids in the northern and southern areas. We believe that especially in the southern areas (Schier, 1988) and to a certain extent also in the northern parts (Poehling and Borgemeister 1989) aphid specific predators particularly syrphids as well as in some years also coccinellids, have proved to be one key factor which regulates the population dynamics of the cereal aphids.

In 1988 and 1989 we simultaneously analysed the population dynamics of syrphids in cereal stands in Hannover and Stuttgart. 1988 in both regions first cereal aphids could be observed nearly at the same time, but only in Hannover a typical gradation followed. In Hohenheim syrphids (mainly Episyrphus balteatus) immigrated about two weeks earlier than in the northern area (Fig. 6). The important (voracious) larval population was established before the aphids reached their highest multiplication rates. However in Hannover syrphid larvae appeared too late to prevent a first strong increase of aphid density. They were mainly responsible only for the accelerated aphid decline.

In 1989 very similar tendencies could be observed (Fig. 6). In this year the pest already reached the high infestation level of more than 2 aphids per plant before booting. Such a density is regularly sufficient to stimulate egg laying of syrphids, but again the syrphids only colonized the fields in the southern area in time. The observed regional differences are probably due to a bad synchronisation in time with different migration pattern between specialists and aphids.

These statements do not mean that syrphids are believed to be the only important regulation factor in the southern areas but the relation between aphid increase and the appearence of syrphids is rather impressive.

The reasons for this observations are still hypothetical today: Ohnesorge (Ohnesorge and Schier, 1989) formulated two possible causes:

1. In the southern parts syrphid development is favoured, as in many other areas in southwestern Germany, too, by the high heterogenity of the landscapes. Aphid predators can easily find suitable habitats close to the fields all year round and especially in spring.
2. The early occurence of M. dirhodum might induce aphid predators to immigrate into the cereals rather early, too.

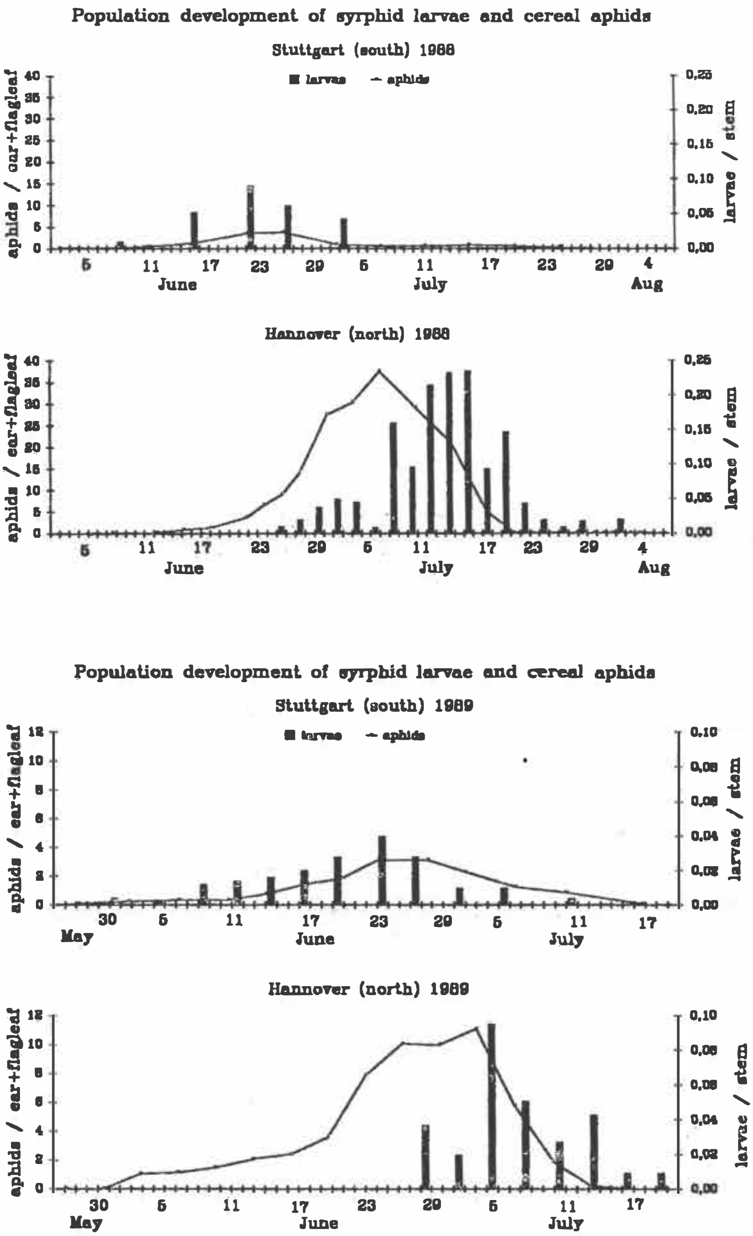


Fig 6 Cereal aphids and syrphid larvae in winter wheat in different regions in Western Germany (1988 and 1989).

These are rather interesting and to a certain degree also convincing arguments, but they do not solely explain all the observations. Especially in 1989 aphid densities in northern areas were higher than in Hohenheim early in the season, probably due to a large amount of succesfully hibernating anholocyclic clones of S. avenae. Climatic conditions for the hibernation of syrphids were also excellent and large colonies of aphids and pollen on early blooming shrubs were available for a possible spring generation, but the syrphids in Hannover still immigrated into the cereals as late as in former years.

It is well known that syrphids can undertake large migrations in autumn and spring. It has to be evaluated whether a long distance migration from southern areas can be responsible for the above described time-lag. Unfortunately we really know nothing today about the hibernation and spring development of the important eurytopic syrphid species in the northern areas of Germany.

Acknowledgement

This work was supported by the German Research Foundation (DFG).

References

Basedow, T., Bauers, C. and Lauenstein, G. (1989). Ergebnisse vierjähriger Untersuchungen zur gezielten Bekämpfung der Getreideblattläuse (Hom., Aphididae) im intensiven Winterweizenanbau: optimaler Termin und Bekämpfungsschwellen. Mitt. Biol. Bundesanstalt, 254.

Entwistle, J.C. and Dixon, A.F.G. (1986). Short-term forecasting of peak population density of the grain aphid (Sitobion avenae) on wheat. Ann. appl. Biol., 109, 215-222.

Hansen, W. (1986). Die Populationsdynamik von Blattläusen an Weizen in Abhängigkeit von der Qualität des Phloemsaftes bei unterschiedlicher N-Düngung. Diss. Universität Göttingen.

Kuo-Sell H.L., Holthusen, C., Quentin, M., Wieduwilt, A. und Wilhelms, A. (1989). Wechselwirkungen zwischen Getreideblattläusen (Homoptera: Aphididae) und Parasitoiden (Hymenoptera: Aphididae) und ihre Bedeutung für die Blattlausbekämpfung in Winterweizen. Med. Fac. Landbouww. Rijksuniv. Gent, 54/3a, 883-893.

Ohnesorge, B. and Schier, A. (1989). Regional differences in population dynamics of cereal aphids and their bearing on shortterm forecasting. Med. Fac. Landbouww. Rijksuniv. Gent, 54/3a, 747-752.

Poehling, H.M. (1988). Influence of cereal aphid control on aphid specific predators in winter wheat. Entomol. gen., 13, 163-174.
Poehling, H.M. and Borgemeister, B. (1989). Abundance of coccinellids and syrphids in relation to cereal aphid density in winter wheat fields in northern Germany. WPRS Bulletin, XII/1, 99-107.
Schier, A. (1988). Untersuchungen zur Populationsdynamik der Getreideblattläuse unter besonderer Berücksichtigung ihrer natürlichen Gegenspieler. Diss. Univ. Hohenheim

Winter wheat aphids in Belgium : prognosis and dynamics of their populations.

LATTEUR, G. (*) and OGER, R. (**)

(*) Station de Zoologie appliquée, Chemin de Liroux, 8, 5030 Gembloux, Belgique.

(**) Bureau d'Informatique et de Statistique appliquées, Avenue de la Faculté d'Agronomie, 22, 5030 Gembloux, Belgique.

SUMMARY

From 1972 to 1989, the evolution of the aphid populations and of their main natural enemies was observed in 90 winter wheat fields in the Belgian cereal area. The observations were made once a week throughout the period of aphid development.

A rational control method against these aphids has been developed. It is based on the knowledge of the influence of the aphids (*M. dirhodum* + *S. avenae*) on the yield according to the importance of their populations and on a simple linear multiple regression model using for the forecast the density of aphids per tiller and that of their main specific enemies (parasitoïds, entomophthorales and larvae of syrphids).at the growth stage "kernel formation".

Finally, the average evolution of populations of cereal aphids and of their specific enemies is commented and compared with the forecast of the general model.

1. Introduction

Metopolophium dirhodum (Walker) and *Sitobion avenae* (F.) appear to be the main summer entomological pests in wheats in Western Europe. However, because of the action of numerous abiotical and chiefly biotical factors, the development of their populations is very variable from year to year and therefore their impact on the cereal yield varies from nought kilo to several hundreds of kilos by hectare. As the years with weak and harmless aphid populations are definitely more numerous than the years with important and harmful ones, it is useful for the profitability of the crop and the protection of environment to try to control these depredators only when this is economically justified.

There are three main methods to help the farmers to manage the protection of their crops against these pests only when need be.

The first one consists in advising the farmer only to act if the aphid density reaches a given treshold, for example one ear out of two colonized by at least one aphid. But he has to do the observations himself and he is the only judge of the seriousness of the situation. It is the method which prevails in France nowadays (Fougeroux 1990).

The second one consists in giving the farmer a scientific and computerized supervision. He is then given advice on condition that he provides a minimum of information, chiefly an observation of the presence or the absence of aphids on a small number of tillers. The first system proposed to farmers is "Epipre" issued from Holland (Rijsdijk & al. 1981). In England the "Prestel Farmlink" system similar to Epipre has been working since 1985 (Wratten & al. 1987).

The third method consists in asking the farmer for no observation at all and in advising him by referring to precise observations made by a team of specialists in reference fields lying in the region to protect. Since 1986 this method has been used in Belgium for 3 reasons :

1) very few Belgian farmers are willing to do the required observations by themselves;

2) the area to protect being small, the situation hardly varies from field to field during the same year and a good prognosis can usually be made for all the fields ;

3) it is better to include the main specific aphid enemies in the prognosis in order to reduce the risk of error, which implies that the observations must be done by specialists.

2. Description of the Belgian advising method.

2.1. *The method*

The prognosis is based on the knowledge of the influence of the aphids (*M. dirhodum* + *S. avenae*) on the yield according to the importance of their populations and on a simple multiple regression model which makes it possible to predict the maximum which should be reached by the populations.

The relationship between the increase in yield obtained after an aphicide treatment and the aphid populations at peak was determined with the results of 40 trials in fields. Thanks to that relationship, it is possible to determine the economic treshold corresponding to the total cost of an aphicide treatment in wheat. So, if in the present economic conditions, one assesses that the cost corresponds to about 170 kg of wheat per hectare one can say that the economic treshold amounts to an average of 10 aphids (*M. dirhodum* + *S. avenae*) per tiller.

As for the predicting model, it makes it possible to forecast the evolution of the aphid populations before they become a nuisance and hence to treat on time if they treaten to reach the economic treshold.

The data used to elaborate the predicting model come exclusively from observations in fields. They have simply consisted in counting *in situ* each species of aphids, the mummies of aphids killed by parasites and entomophthorales as well as the larvae of ladybirds and syrphids.

In 1987 (Latteur & Oger 1987) a first model was elaborated. The model has been actualized recently by adding the data collected during these last four years. This model groups together data collected from 1971 to 1989 in 90 winter wheat fields.

The prognosis is made shortly after flowering at the growth stage "kernel formation", which lasts 5 to 10 days (Keller & Baggiolini 1954). The first reason why it has been decided to forecast at this stage and not before, appears on table 1. The correlation between aphid populations at earing and flowering growth stages and at peak is too weak to allow to make an accurate forecast. But at the growth stage "kernel formation" this correlation is acceptable.

Tabel 1 : Correlations between the aphid populations at peak and their populations at different growth stages (19 years - 90 fields)

Earing	Flowering	Kernel formation	Kernel watery ripe
0,12	0,35	0,77	0,89

The second reason is that, at growth stage "kernel formation", the natural enemies may already be present in sufficient numbers to play an efficient regulation role. As one can see in table 2, at this stage, the correlations between the densities of the natural specific enemies and those of aphid populations at peak are far from being negligible except for ladybirds which have very rarely played an important role in the observed fields.

Table 2. : Correlation between the aphid populations at peak and the density of their specific enemies at the growth stage "kernel formation" (19 years - 90 fields).

Mummies of		Larvae of	
Parasitoïds	Entomophthorales	Coccinellids	Syrphids
-0,53	-0,32	-0,04	-0,28

The third reason is that the aphid populations are always too insignificant at growth stage "kernel formation" to be harmful to the yield even if they may exceed the economic treshold later (Latteur & Oger, 1987).

At last, the fourth reason lies in the fact that from that growth stage on, the cereal is less likely to be infected by aphids. So a possible aphicide treatment protects it from any further reinfestation which is not neccessarily true before kernel formation.
The model can be used 1°) for a general prognosis (general model) valid for all the observed fields and by extrapolation for all the fields of a whole area 2°) for one field in particular (individual model).

Equation of the general model.

log (NBMAX+1) = 1,364+0,734 log (NBM+1)-0,0064 PARM-0,0625 log (NBMYCM+1)-0,0573 SYRM.

R^2 (adj.) = 63,9 %

Equation of the individual model

log (NBMAX+1) = 0,918+0,222 log (NB+1)+0,668 log (NBM+1)-0,0031 PAR-0,0023 MYC-0,0142 SYR

R^2 (adj.) = 62,7 %

NBMAX = number of aphids (*S. avenae* + *M. dirhodum*) per 100 tillers at peak.

NBM = geometrical mean of the number of aphids per 100 tillers observed in the fields.

NB = number of aphids per 100 tillers observed in the field.

PARM = average number of mummies of parasitoïds per 100 aphids

NBMYCM = average number of mummies of aphids killed by fungi per 100 aphids

SYRM = average number of larvae of syrphids per 100 aphids

PAR, MYC and SYR = number of mummies of parasitoïdes, of mummies of aphids killed by fungi and of larvae of syrphids per 100 aphids.

It is noteworthy that the equation of the individual model includes the geometrical mean of the number of aphids recorded in all the observation fields in order to take the general tendancy of the aphid dynamics into account.

2.2. *Importance of the natural enemies in the forecast*

As far as the natural enemies are concerned, we have tried to evaluate, in the individual model, the increase in accuracy brought by the data concerning the parasitoïds, the entomophtorales and the larvae of syrphids, which are in general the main auxiliairies (table 2). The answer lies in the comparison of tables 3 and 4.

Table 3 gives the number of right and wrong prognosis (in a circle) which are made when natural enemies are not taken into account. Table 4, on the contrary, indicates the number of right and wrong prognoses when the natural enemies are taken into account.

Table 3 : Prognosis made without taking the parasitoïds, the entomophthorales and the larvae of syrphids into account : number of right and wrong O prognosis.

Number of aphids observed at peak	Number of fields for which the prognosis is : < 10	> 10
< 10	61	(3)
> 10	(9)	17

Table 4 : Prognosis made by taking the parasitoïds, the entomophthorales and the larvae of syrphids into account : number of right and wrong O prognosis.

Number of aphids observed at peak	Number of fields for which the prognosis is : < 10	> 10
< 10	61	(3)
> 10	(6)	20

In the first case (when natural enemies are not include), one can notice that, if the true number of aphids observed at peak is inferior to 10, the model gives 61 right prognoses and 3 wrong ones. On the contrary, if the true peak is superior to 10, there are 17 right prognoses and 9 wrong ones.

If the model takes natural enemies into account, the number of wrong prognoses when the true number of aphids at peak is inferior to 10 remains egual to 3. On the other hand, when the true peak is superior to 10, the number of wrong prognoses is 6 instead of 9 which shows clearly that it is important to take the natural enemies into account.

3. Dynamics of aphid populations and comparison with the general forecasting peak in some specific years.

The results (figures n° 1 to n° 11) relate to the 11 years (1972, 73, 80 to 83 and 85 to 89) for which there were observation data in at least 5 fields. The figures also show :

1.- the number of aphids forecast at peak (Prog. = ..aph/til.);

2.- the forecast moment (the arrow) which is also that of the growth stage "kernel formation";

3.- the number of degree days superior to 10 degrees [which is according to Carter & al, (1982) the physiological zero of *S. avenae*] and, between brackets, the normal degree days.

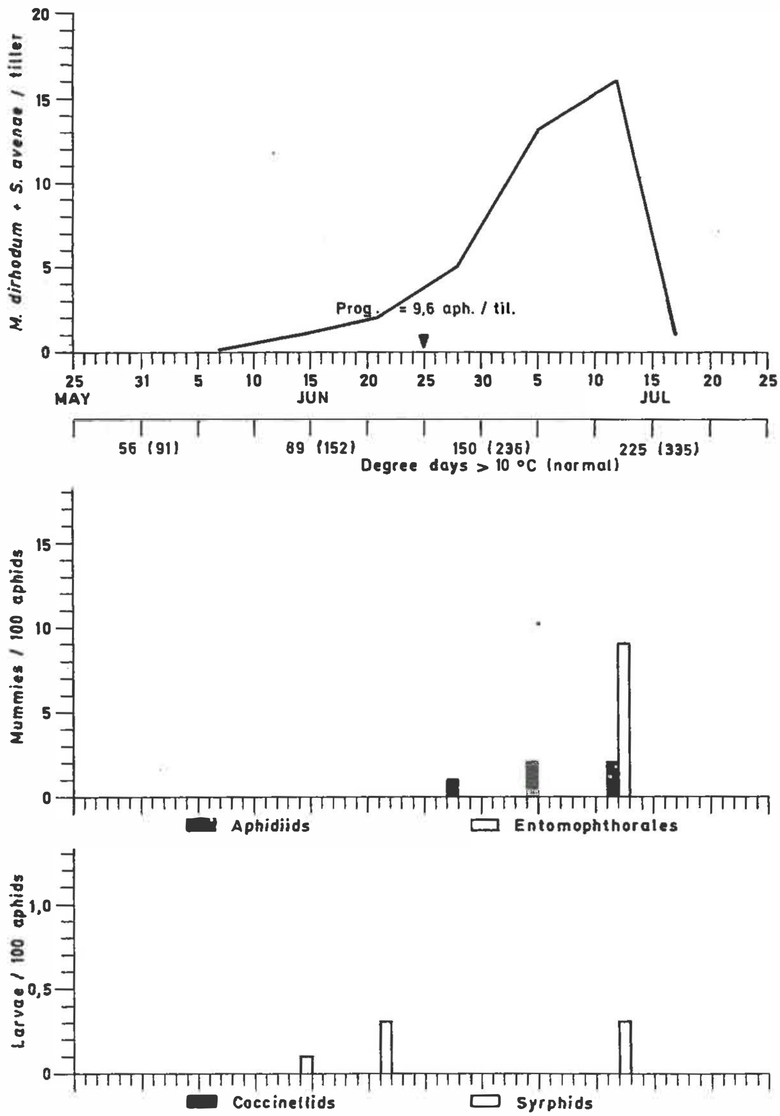


Fig.1. Average density of aphids and their specific enemies in 7 winter wheat fields in 1972.

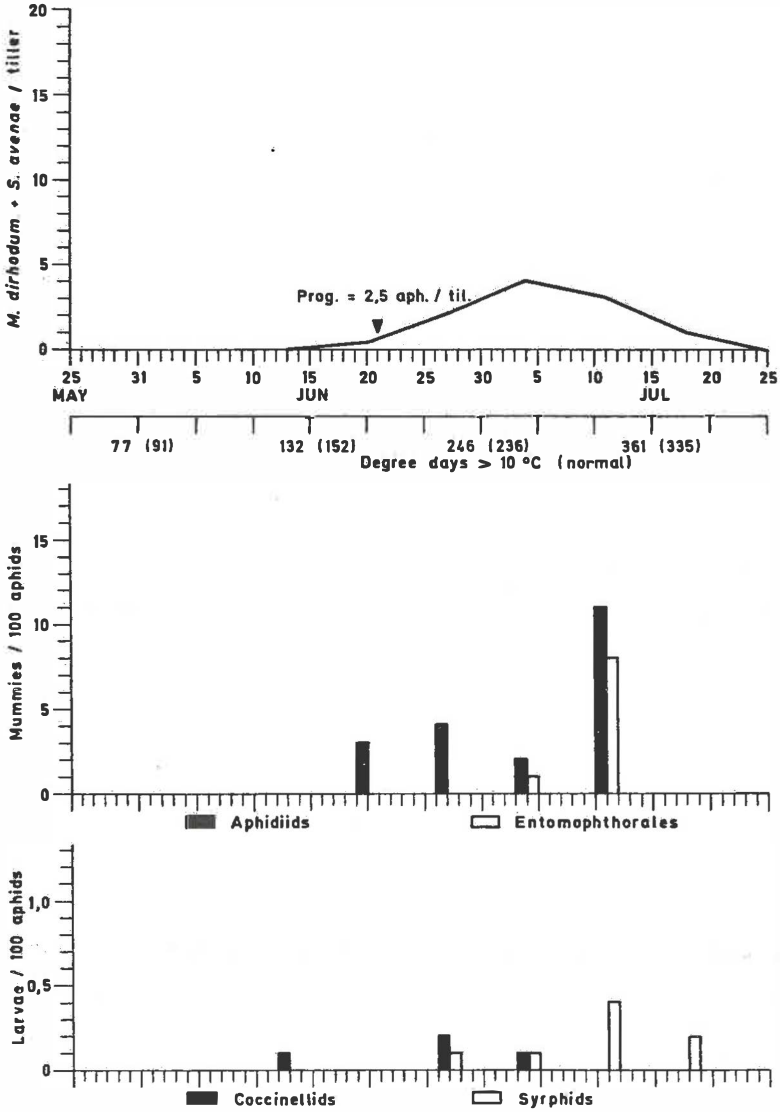


Fig.2. Average density of aphids and their specific enemies in 9 winter wheat fields in 1973.

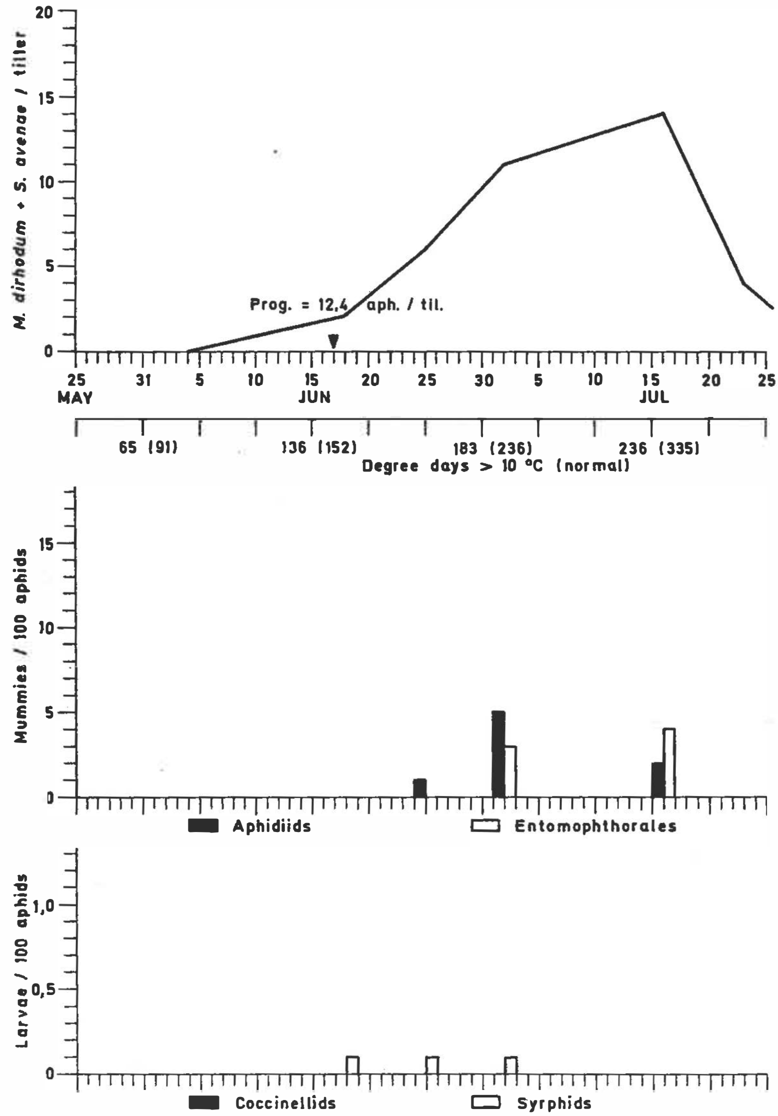


Fig.3. Average density of aphids and their specific enemies in 6 winter wheat fields in 1980.

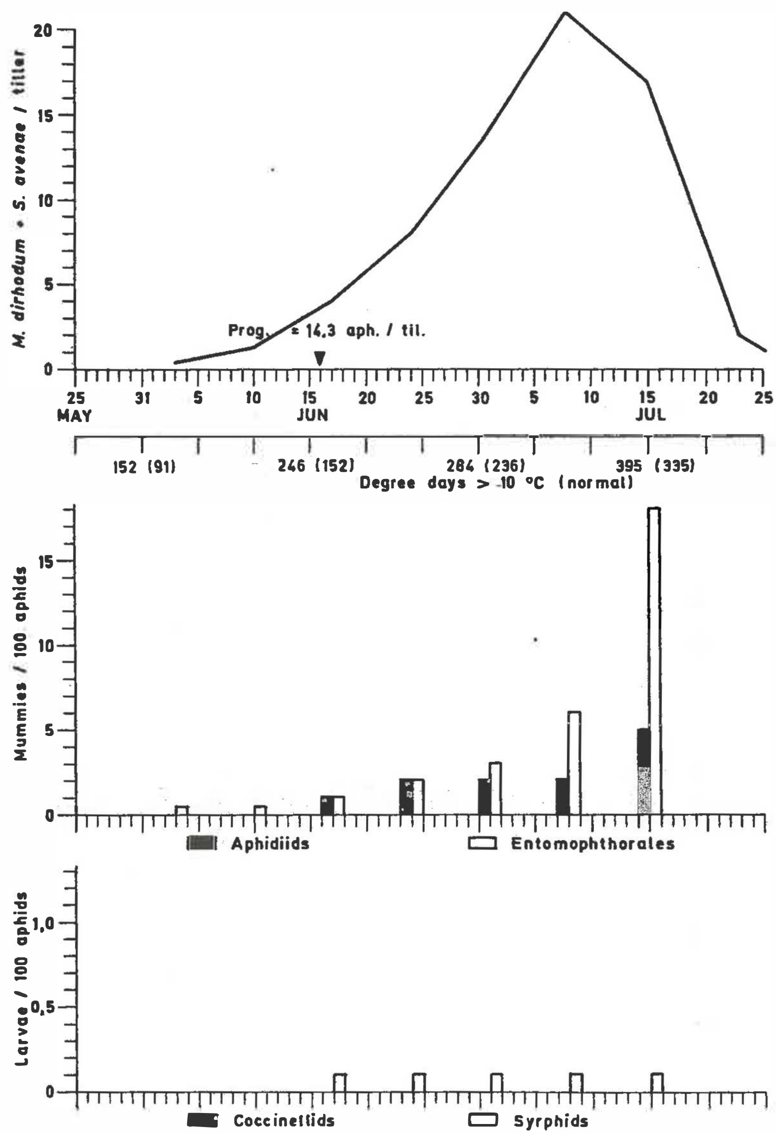


Fig.4. Average density of aphids and their specific enemies in 10 winter wheat fields in 1981.

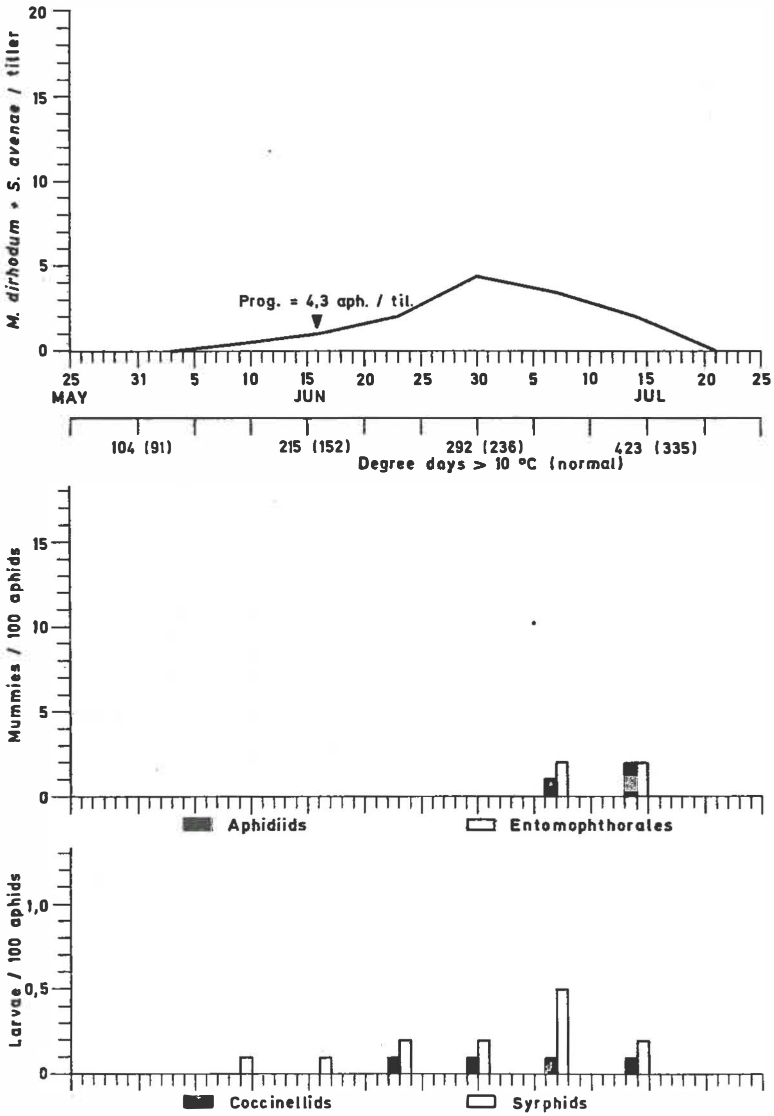


Fig.5. Average density of aphids and their specific enemies in 8 winter wheat fields in 1982.

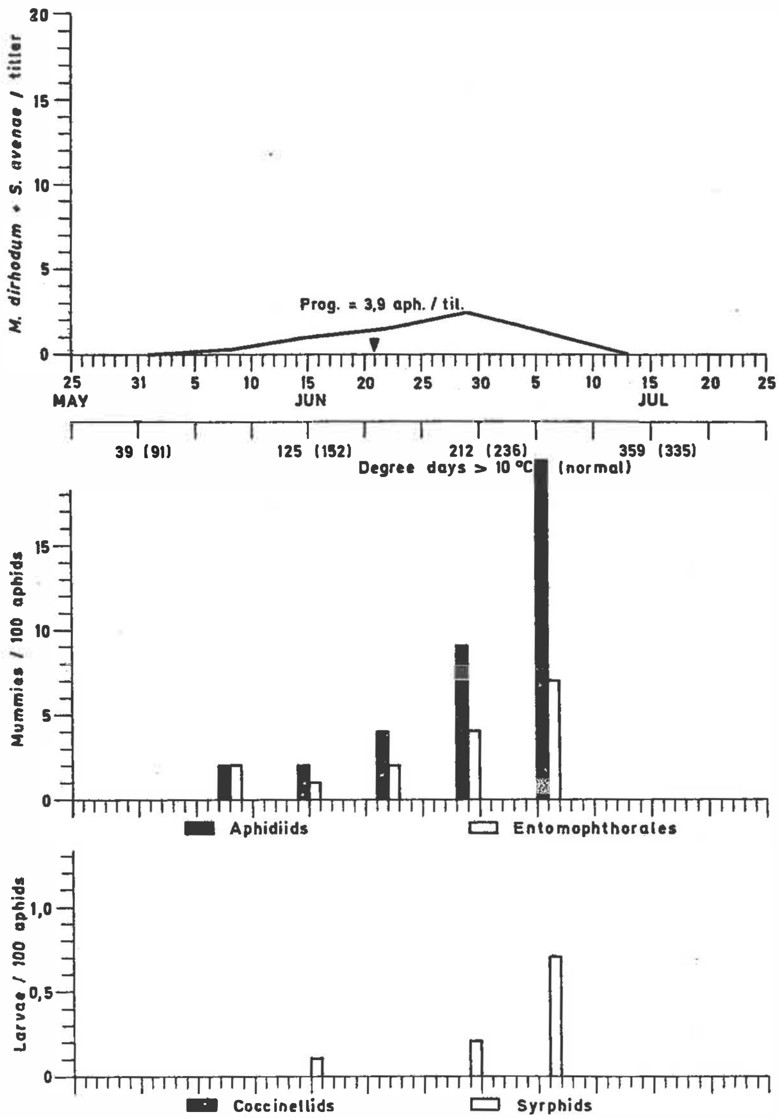


Fig.6. Average density of aphids and their specific enemies in 7 winter wheat fields in 1983.

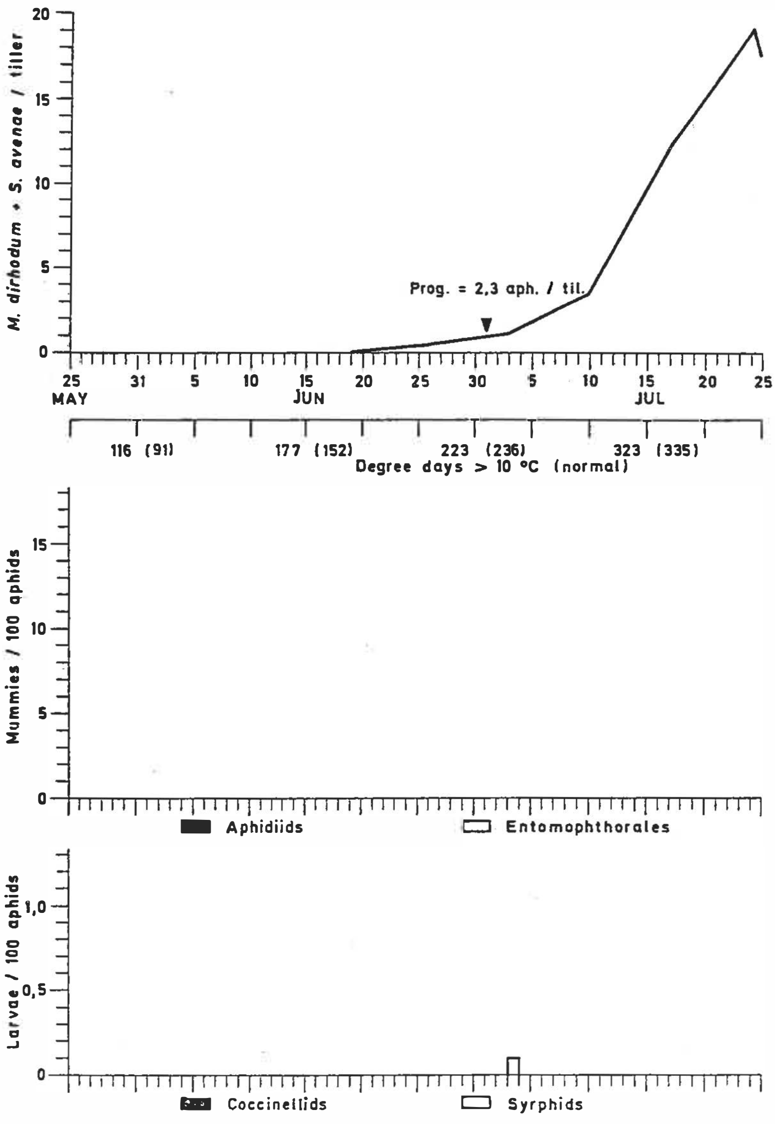


Fig.7. Average density of aphids and their specific enemies in 8 winter wheat fields in 1985.

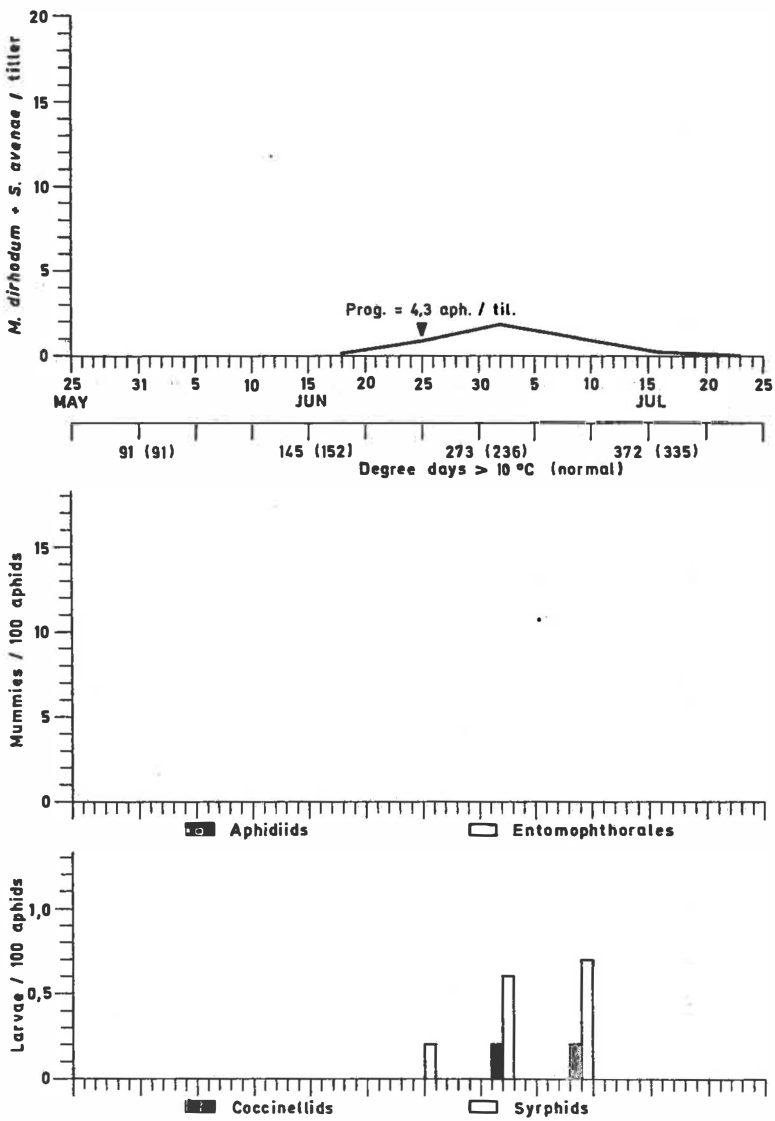


Fig.8. Average density of aphids and their specific enemies in 7 winter wheat fields in 1986.

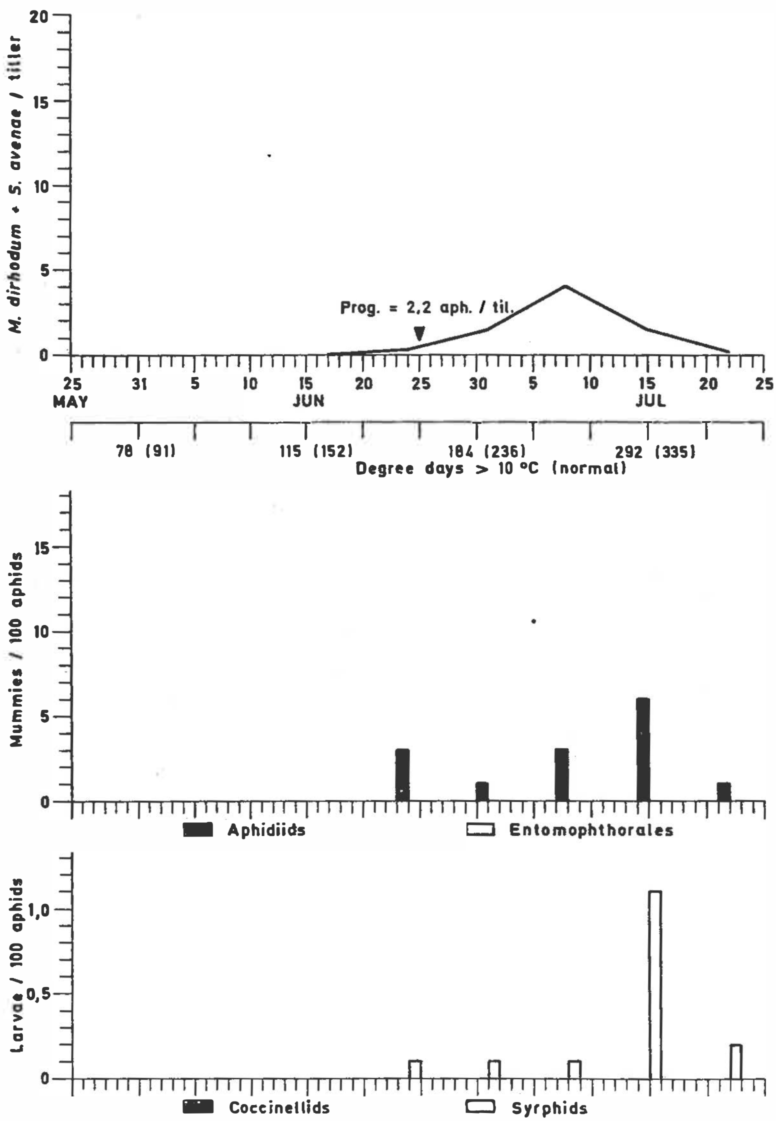


Fig.9. Average density of aphids and their specific enemies in 7 winter wheat fields in 1987.

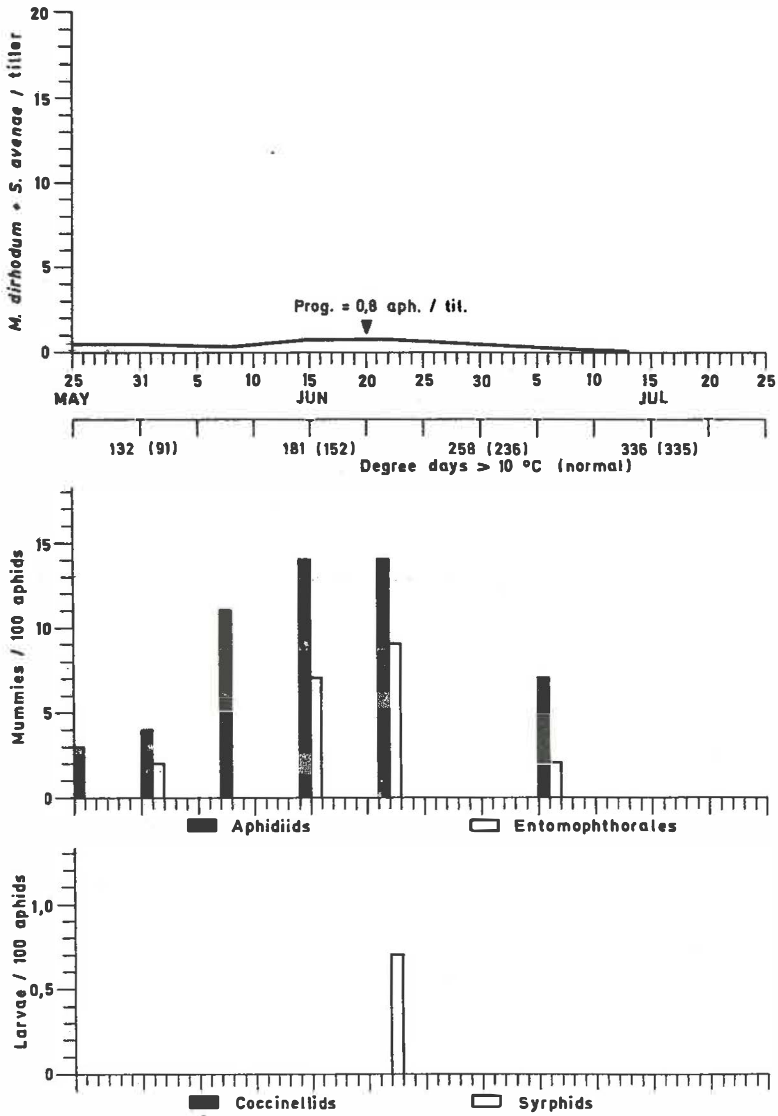


Fig.10. Average density of aphids and their specific enemies in 5 winter wheat fields in 1988.

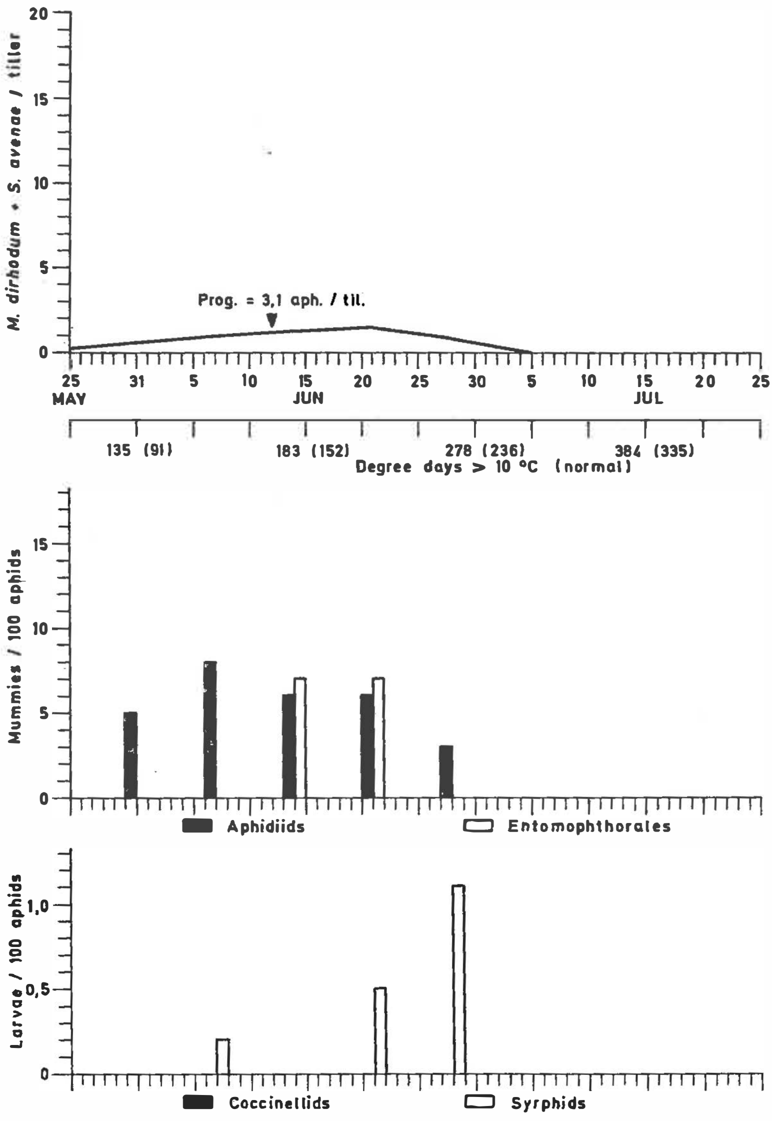


Fig.11. Average density of aphids and their specific enemies in 6 winter wheat fields in 1989.

3.1. Winter influence

The earliest development of aphid populations was observed by the end of May after the mildest winters (1988 and 89) (Table 5) whereas the latest one occurred about June 15 - 20th and came after the harshest winters (1985, 86, 87) even when spring was rather warm as in 1985.

In the course of 11 years as related here, the average aphid populations in the experimental fields have definitely outnumbered 4 times (in 1972, 80, 81, 85) the economic treshold of an average of 10 aphids per tiller. There have been quite mild winters during the first two years, a normal one in 1981 and a cold one in 1985. The seven years during which the aphid development was inferior to the economic treshold have never recorded populations superior to 5 aphids per tiller. There have been mild, normal or harsh winters.

These observations seem to prove that if the rigour of winter has an influence on the precocity of the arrival of aphid populations in the wheat fields, it does not influence the importance of the latter in the good season.

Table 5 : Number of days for which the minimum temperature is inferior to 0° C, - 5° C, - 10° C, - 15 ° C, and - 20° C during the winter months (December, January, February, March).

/////////	Number of days for which the minimum temperature is				
Year	< 0° C	< -5° C	< -10° C	< -15° C	< -20° C
1972	43(*)	6	2	0	0
1973	62	6	0	0	0
1980	43	10	0	0	0
1981	60	11	0	0	0
1982	67	17	6	3	1
1983	53	12	0	0	0
1985	70	28	23	7	0
1986	68	32	13	2	0
1987	70	32	7	2	0
1988	38	5	0	0	0
1989	23	0	0	0	0

(*) normal number = 56

3.2. Influence of temperatures in June - July.

We have already observed (Latteur, 1989) that the correlation coefficient referring to the number of aphids (*S; avenae* or *M. dirhodum*) at their peak and to the temperatures in June is definitely negative. This is confirmed by the observation of the results of these 11 years, namely if one compares the 1972 results with those obtained in 1982. Indeed, while the aphid density and that of their specific enemies were quite similar by 15th June, the aphids reached a maximum average number of 17 in 1972 and of 4 in 1982 while the number of degree days superior to 10° C from 15th June to 15th July was far weaker in 1972 (136) than in 1982 (208). However, 1972 is also different from 1982 because of populations of less important predators larvae after 15th June and because of a less early cereal growth stage (stage "kernel formation" observed on 25 th June in 1972 and 16th June in 1982), two factors which may have been more important than the temperature on the evolution of aphid populations.

3.3. The specific enemies

The specific enemies are not the only regulation biotic factors of cereal aphids. The polyphagous predators (*carabidae*, *staphylinidae* and araneae) that are not recorded in this study may also play a non-negligible limitation part (Vickerman & Wratten, 1979; Sunderland & al., 1986). Moreover, the phenology of the cereal may influence the multiplication rate of aphids. The whole of these biotic and abiotic factors makes the comprehension of the dynamics of aphid populations very difficult. The statistical analysis of the data (ch. 2) though, has enabled us to evaluate the average relative importance of each of the specific enemies, which is a first step to the quantification of their action.

Besides, one will note that all the years with weak aphid populations (≤ 5 aphids/tiller) have in common the fact that at least one specific enemy is observed from the appearance of aphids on and often maintains itself at a relatively high level during the whole development of aphid populations : parasitoïds in 1973, 88 and 89, syrphids in 1982 and 86, parasitoïds and entomophthorales in 1983 and at last parasitoïds and syrphids in 1987. On the contrary, the years of outbreak (≥ 15 aphids per tiller) go together with sporadic and rather weak presence of specific enemies except in 1981 when entomophthorales, parasitoïds and syrphids were to be found, at rather weak levels however, during almost the whole development of aphid populations, without any decrease in the density of the latter before the beginning of July.

Rabasse and Dedryver (1982) relate that parasitoïds of cereal aphids may multiply during mild winters in the French Brittany on anholocyclic forms of these aphids, which enables them to be often present in spring in numbers allowing them to play a significant regulation role.

This behaviour seems to be the same in our regions too, as :

1°) a rather great density of mummified aphids were observed in 1988 and 1989 after a very mild winter and in 1983 after a moderate one winter as soon as the aphids appeared in wheats by the end of May (1988 and 89)-beginning of June (1983) and they seem to have played an important regulation role ;

2°) during the harsh 1982, 85, 86 winters aphidiid mummies were not observed in wheats (1985 and 1986) or appeared very late, by the beginning of July (1982).

We have observed however that, after the harsh 1987 winter, mummies of parasites appeared in rather important numbers as soon as the aphids had colonized the wheats. This might be the result of the fact that, during some years, these parasites can also winter in diapause and so, be quite frost-proof.

The entomophthorales have been recorded at least once every year during the observation except in 1985, 86, 87, that is after the harshest winters and for unknown reasons. When they are present, it is in a more sporadic way than the parasites, except in 1981 and 83, when they were observed continuously. Their maximum development is observed when the aphid starts decreasing or shortly after it. Their importance, however, does not seem to depend exclusively on that of aphid populations as we observed twice, in 1988 and 89, about 8 % of mummified aphids - that is quite a lot - in weak aphid populations (from 1 to 2 aphids/tiller).

Syrphid larvae have been recorded in the aphid populations at least once a year. The importance of their density does not seem to be influenced by the harshness of the winter. These predators are often observed in weak aphid populations (an average of 1 aphid/tiller). They are almost as frequent as the aphidiides but they appear a bit later, at the earliest by the beginning of June instead of the end of May, like the parasites. When the aphid populations are increasing, their density can reach 0,7 larva for 100 aphids.

Ladybird larvae are the least frequently observed among the specific enemies. They have only been recorded during 3 years (1973, 82, 86) out of 11 and their densities have not exceeded 0,2 larva for 100 aphids.

Larvae and adults of chrysopids have rarely been observed and anyway in too weak quantities to be recorded in our results.

3.4. <u>Comparison of the general forecasting peaks with those observed.</u>

By comparing, in figures 1 to 11, the average maximum number of aphids forecast by the general model at growth stage "kernel formation" and that really reached by the populations, the precision of the model can be evaluated.

So, it appears that the average number of aphids forecast is superior to that observed in 1983, 86, 89, is similar in 1982 and 88, and is inferior in 1972, 73, 80, 81, 85 et 87.

The general model seems to underestimate more often than it overestimates, which is probably regrettable for farmers as we think it better to advise a treatment unnecessarily than the contrary.

However, the main thing is to advise accurately in connection with the economic treshold. It is thus reassuring to notice that when the latter amounts to an average of 10 aphids/tiller the advise to treat or not to treat has proved inadequate only 1 year (1985) out of 11. Moreover, this good counsel would be right even if the treshold were, for economic reasons, reduced up to 5 aphids/tiller, which is still more reassuring.

4. Conclusions.

As a conclusion, it is important to point out that within 20 years of field observations on cereal aphids, we have not met twice the same situation. Figures 1 to 11 are a good illustration of that great variability.

The number of factors influencing the dynamics of aphid populations is often so large that it is difficult to identify the true causes of the evolution observed except in very rare cases such as the nearly absolute absence of benefical organisms in 1985 or the dominance of parasitoïds in 1989.

It is the reason why the field biologist who wants to forecast the development of aphid populations with a maximum of accuracy must admit that dynamic or regression models have become unavoidable tools.

5. Bibliography

CARTER, N. DIXON, A.F.G. & RABBINGE, R. 1982. Cereal aphid populations : biology, simulation and prediction. *Wageningen . Centre for Agricultural Publishing and Documentation* : 1 - 91.

FOUGEROUX, A. 1990. Les ravageurs du blé d'hiver au printemps. *Phytoma*, 4/6 : 47-50.

KELLER, Chr. & BAGGIOLINI, M. 1954. Les stades reprères dans la végétation du blé. *Revue Romande d'Agriculture de Viticulture et d'Arboriculture*, 10, 3 : 17-20.

LATTEUR, G. 1989. Pucerons : Epidemiologie et prognose. Application aux pucerons des froments d'hiver, des betteraves et des plants de pommes de terre en Grande-Bretagne, en France et en Belgique. *"Euraphid" network : Trapping and aphid prognosis.* Edited by R. Cavalloro. C.E.C. Eur. 11.559 : 131-148.

LATTEUR, G. & OGER, R. 1987. Principes de base du système d'avertissement relatif à la lutte contre les pucerons des froments d'hiver en Belgique. *Annales A.N.P.P.*, 6, II/III : 129-136.

RABASSE, J.M. & DEDRYVER, C.A. 1982. Overwintering of primary parasites and hyperparasites of cereal aphids in Western France. *Aphid Antagonists* . Edited by A.A. Balkema, Rotterdam : 57-64.

RIJSDIJK, F.H., LEEUWEN-PANNEKOEK, I., RABBINGE, R. & ZADOKS, J.C. 1981. EPIPRE, een begeleidingssysteem voor bestrijding van ziekten en plagen in wintertarwe. *Gewasbescherming*, 12 (1) : 10.

SUNDERLAND, K. D., FRASER, A.M. & DIXON, A. F. G. 1986. Field and laboratory studies on money spiders (*Limyphiidae*) as predators of cereal aphids. *Journal of Applied Ecology*, 23 : 433-447.

VICKERMAN, G.P. & WRATTEN, S.D. 1979. The biology and pest status of cereal aphids (Hemiptera : Aphididae) in Europe : a review. *Bull. ent. Res.* 69 : 1-32.

WRATTEN, S., MANN, B. & WATT, A. 1987. Un système d'aide par ordinateur pour le contrôle des pucerons des céréales et des ravageurs du colza. *Annales A.N.P.P.*, 6, I/III : 53-63.

A model-based catalogue of case studies as a tool for decision making in the control of the cereal aphid *Macrosiphum [Sitobion] avenae* in winter wheat

by F. HOLZ

Martin-Luther-Universität Halle-Wittenberg,
Sektion Pflanzenproduktion,
Lehrstuhl Phytopathologie und Pflanzenschutz,
Ludwig-Wucherer-Straße 2, 4020 Halle (S.) (G.D.R.)

Introduction

The forecast of population dynamics of *Macrosiphum [Sitobion] avenae* is complicated because the increase of abundance from tillering up to the milky ripe of wheat is influenced by numerous driving variables. By this reason several control thresholds were recommended by different authors in the past. WETZEL and FREIER proposed already 1975 as threshold 3 to 5 aphids per ear to the time end of flowering/begin of milky ripe. This control threshold is used until nowadays in the G.D.R. and it represents a good help for decision making. But the flexibility of such tools is restricted. Therefore a simulation model was developed for the population dynamics of *M. avenae*.

The model

The model was created by FREIER (1983) and validated by HOLZ (1986). PESTSIM-MAC is the short name of the model. It is based on the concept of SONCHES, a Simulator Of Nonlinear Complex Hierarchic EcoSystems (KNIJNENBURG et al., 1984). This simulator includes tools for the building, evaluation and application of models of ecosystems. SONCHES is a branch-specific simulation system for the design of dynamical, explaining, modular, time- and space-discrete, flexible models. SONCHES is written in FORTRAN IV and it works under

TABLE 1

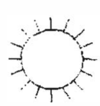
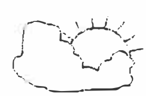
Characteristics of inputs for a catalogue of case studies for field-related decision making in the control of *Macrosiphum [Sitobion] avenae* in winter wheat (DC 69)

input variable	case	value	remarks
weather	warm and dry	19°C; 13.5mm	average value of daily mean
	normal	16°C; 29.1mm	temperatures and sum of
	cold and wet	15°C; 80.1mm	precipitation in the period DC 60-78
parasitation	low	2%	percentage of mummified aphids
	middle	8%	in relation to the whole
	high	20%	aphid population
abundance of predators	low	1	number of predator units / m^2 1 predator unit = 1 adult ladybird
	middle	5	or 2 larvae of ladybirds,
	high	15	hoverflies or lacewings
age structure of aphid population	young	13%	percentage of adults
	normal	20%	(winged and unwinged)
	old	26%	in the aphid population

TABLE 2

Commendable thresholds (aphids/ear) for field-related decision making in the control of *Macrosiphum [Sitobion] avenae* in winter wheat to the stage DC 69

(catalogue of case studies)


parasitation rate	abundance of predators	young	normal	old	young	normal	old	young	normal	old
low	low	1,0	1,1	1,1	1,3	1,4	1,5	2,2	2,3	2,4
	middle	1.4	1,5	1,6	2,0	2,1	2,2	3,2	3,4	3,5
	high	3,0	3,2	3,3	4,0	4,3	4,6	6,1	5,8	6,3
middle	low	1,7	1,6	1,5	2,4	2,2	2,0	4,1	3.7	3.4
	middle	2,4	2,3	2,1	3,5	3,3	3,1	5,9	5,3	4,9
	high	5,0	4,6	4,4	6,8	6,4	6,2	8,1	7,1	7,3
high	low	3,3	2,7	2,1	5,0	4,1	3,1	8,4	6,8	5.3
	middle	4,8	4,0	3,1	7,1	5,9	4,7	9,0 *	7,7	7,4
	high	9,0	7,8	6,4	10,0 *	10,0 *	9,0	7,9 *	9,3	9,2

the operating systems VAX and MSDOS.
PESTSIM-MAC describes the development of the aphid population from the beginning of immigration into the wheat stand in spring up to the decline. It considers the most important driving forces like weather, parasites, predators and condition of host plant. Model structure and process algorithms are explained by ROSSBERG et al. (1986).
Why was such an extended model constructed?
The security and accuracy of control thresholds seems insufficient as mentioned. Secondly investigations of control strategies and hypothesis about real processes are possible which can't be tested in laboratory or under controlled conditions. Moreover a model of this type integrates knowledge from various sources. In this way a memory is created which also may contain so-called soft data. The discovering of gaps in knowledge is one important result of such an abstraction by a model.
The possibilities for application of a well-structured and validated(!) model on practical purposes depends on several factors like quality of the model, complexity and handling of model, technical conditions and others. An on-line and problem-oriented application by the final user appears as the best and easiest way. Unfortunately PESTSIM-MAC is too complex and time-consuming for an on-line or an individual usage by the farmer or by the plant protection specialist. So there is the demand of searching for a quite easy form of application. The idea of a catalogue of case studies could solve this problem.

The catalogue of case studies

The basic assumption is that the abundance dynamics of a pest are determined to a large scale by only few driving factors. These key factors should have some typical manners of behaviour during a couple of years. So it would be possible making simulation studies for various constellations of such typical cases of the dynamics of certain variables. The headline for this investigations could be "What happens, if...?".

TABLE 3

Evaluation of the catalogue of case studies for *Macrosiphum [Sitobion] avenae* in winter wheat (DC 69) by retrospective application on real field-data

year	place	variety	control threshold selected from catalogue		real abundances DC 69	maximum
1980	Peißen	Alcedo	1.4		0.3	5.2
1981	Peißen	Alcedo	6.8		0.1	0.6
1982	Peißen	Alcedo	1.1		1.1	10.0 !
1984	Peißen	Alcedo	1.0		0.1	3.7
		Taras	1.0		1.3	11.0 !
	Schnellroda	Fakon	1.1		0	1.2
		Taras	1.1	[aphids/ear]	0.1	1.4
1985	Peißen	Alcedo	2.2		0.2	1.5
	Schnellroda	Alcedo	2.2		0.1	0.9
		Regina	2.3		0	1.4
		Fakon	2.3		0	0.4
1986	Peißen	Alcedo	1.1		0.5	2.4
	Schnellroda	Galahad	1.1		1.9	insecticide used !
1987	Peißen	Alcedo	1.3		0.3	1.0
1988	Peißen	Alcedo	1.3		0.6	1.8
1989	Peißen	Borenos	7.8		2.4 *	2.4

Weather, parasitation rate, abundance of predators and age structure of aphid population were choosed as variables for the case studies with PESTSIM-MAC. It seems enough if there are considered three cases of typical behaviour for every variable in relation to the development of aphid population: best, normal and worst case. At last that means $3^4 = 81$ imaginable constellations. An important problem is the providing of suitable data. The use of pure artificial data is questionable. Therefore the author created "synthetic data with a real background". What does it mean? The long-period average dynamics of every selected variable were defined as "normal case". Then the rows of data were constructed by the combination of fit segments from real data sets. The data material for "best case" and "worst case" was put together in the same way. Table 1 supplies an overview of characteristics of driving variables. Now the model computings were made on this data base. The results of simulations are not fixed values but population curves because PESTSIM-MAC is a dynamical model. So it would be possible giving a forecast of abundance dynamics up from every date. But the restricting fact is the uncertainty of prognosis of driving forces (especially weather). On the other hand it is more easy using fixed values to a fixed date in practice.
So only the short intervall between DC 69 and DC 73 is favourable for decision making to control *M. avenae*. Therefore the results of case studies are presented for the end of flowering stage of winter wheat (DC 69) as the right moment for decision making (table 2). Every number in table 2 embodies a threshold. A significiant damage has to be expected if the selected level is reached or passed. The thresholds are valid for an expected yield of 60 to 70 dt/ha. If higher yields are expected a small reduction of table value is recommended.

Following general findings are detectable from the case studies:

- The threshold of the "total normal case" (i.e. all driving variables show their "normal" dynamics) is situated exactly in the intervall of the mentioned control threshold of WETZEL and FREIER (1975). So both thresholds confirm each other.

- The scope is much greater for decision making by the catalogue than by control threshold. Moreover the catalogue allows a real quantitative forecast in opposite to the control threshold which is a kind of negative (=indirect) prognosis.

- The catalogue permits taking account to the most important driving factors in well-graded steps.

- The following relation-shape shows the relative importance of each driving force in comparison to the others:

  weather ≅ parasitation ≅ predators >> age structure.

  The conclusion is that there is no necessity of noticing the age structure of aphid population in practice. So it is recommended that the case "normal age structure" should be used normally.

- Numbers marked by "*" (table 2) show a very interesting fact. In this cases the abundance has reached or even passed their maximum to this early time. This sentence supports the hypothesis that antagonists are able to regulate the aphid population development below the economic threshold if the enemies appear early and in a great number. That demands an involving of the abundance of predators and the parasitation rate into the supervising and decision making.

The catalogue was tested by an application on real data. Provided that the assumption is right that a significant damage is caused if the abundance maximum reachs 10 or more aphids/ear the catalogue would have recommended right decisions in all tested cases as the results illustrate (table 3). Although the abundance reached only four times a dangerous level the security and accuracy is quite good. The data from 1989 (marked by "*") supply an important evidence. Already to the end of flowering has the abundance reached

their maximum. This soon decline was caused by enemies.
Easy can the catalogue be handled in the proposed manner if it is simplified by removing the cases "young" and "old" age structure. So the catalogue could be a real alternative to the control threshold.
A further improvement of catalogue is imaginable. Following factors could be involved:

- differences of wheat varieties in resistance (in widest sense) against aphid infestation,
- expected yield,
- length of period of milky ripe of winter wheat which is most important for the extent of damage caused by aphids,
- other control strategies.

Moreover it should be proved if a computer-based decision program is needed (for example as a part of a management system).

References

FREIER, B. (1983) Untersuchungen zur Struktur von Populationen und zum Massenwechsel von Schadinsekten des Getreides als Grundlage für ihre Überwachung, Prognose und gezielte Bekämpfung sowie für die Entwicklung von Simulationsmodellen. Halle-Wittenberg, Martin-Luther-Univ., Diss. B, 246 pp.

HOLZ, F. (1986) Einschätzung, Vervollkommnung und Nutzung von Simulationsmodellen für die Populationsdynamik von Schadinsekten des Getreides, dargestellt am Beispiel der Getreidelaus (*Macrosiphum avenae* [Fabr.]), Halle-Wittenberg, Martin-Luther-Univ., Diss., 99 pp.

KNIJNENBURG,A., MATTHÄUS,E. & WENZEL,V. (1984) Concept and usage of the interactive simulation system for ecosystems SONCHES. *Ecological Modelling* 26, 51-76.

ROSSBERG, D., HOLZ, F., FREIER, B. & WENZEL, V. (1986) PESTSIM-MAC. A model for simulation of *Macrosiphum avenae* FABR. populations. *Tagungsberichte der Akademie der Landwirtschaftswissenschaften der DDR* 242, 87-100.

WETZEL, Th. & FREIER, B. (1975) Kenntnis der Vermehrungspotenz und des Massenwechsels von Getreideblattläusen als Voraussetzung zur Prognose und gezielten Bekämpfung. *Archiv für Phytopathologie und Pflanzenschutz* 11, 133-152.

ON THE OCCURENCE AND CONTROL OF INSECT PESTS AFFECTING WINTER WHEAT EARS IN PRACTICE

Christa VOLKMAR(*) and Th. WETZEL(*)

(*) Martin-Luther-Universität Halle-Wittenberg, Landwirtschaftliche Facultät, Institut für Phytomedizin, Ludwig-Wucherer-Straße 2, HALLE/SAALE 0-4020 F.R.G.

SUMMARY

Analysis of the occurence of insect pests affecting winter wheat ears and of the scale of damage revealed cereal aphids and wheat midges to be capable of gradation in high-intensity grain production in the district of Halle.
The Thysanoptera affecting cereals continue to be latent pests doing harm to winter wheat. The optimal dates for control of wheat midges and cereal aphids are reached at different stages of plant development. After the threshold value has been exceeded, *Contarinia tritici* (Kirby) is reliably controlled at the begin of ear emergence (DC 50 to DC 53) and *Macrosiphum avenae* (Fabr.) at the end of winter wheat flowering (DC 68 to DC 70). Carefully directed treatment of one insect pest influences also the development of the populations of other insect pests that affect the ears. These interactions should be considered when drawing up decisions for control action.

INTRODUCTION

In recent years several statements were made about the significance of a purposeful application of chemical agents against cereal pests in the framework of integrated pest control (WETZEL, 1983 ; WETZEL and SPAAR, 1965). In this connection special attention has been given to the control of the agroecosystem and its response to chemical agents.

In order to avoid arbitrary and routine applications of chemicals, it is necessary to monitor the incidence of different pest species in winter wheat crops and to investigate the economical and ecological benefits of integrated control measures in a large-scale trial. When doing so, all activities must be directed on the cereal plant and the reliability by yield and quality. Pest control is supposed to interfere as a kind of regulator into the population structure of one or more pest species, if other measures, especially crop and soil cultivation, can not avoid a gradation of the pest and the involved yield losses.

The aim of the production trial carried out between 1983 and 1987 was to study the effect of the insecticides metamidophos and dimethoate on the population development of ear pests in winter wheat crops under naturally differentiated conditions of incidence and, furthermore, to give recommendations for a purposeful practicing of plant protection measures. The experiments were orientated on a combined incidence of the ear pests : cereal aphids, wheat midge and cereal thrips.

METHODS

The experiments were established in the coöperative farm for crop production Barnstädt, Halle district. The test fields covered an area of to 100 hectares, their length being about 500 metres. Chemicals were applied in stripes by means of ground machinery using the resulting pass-ways. The two test variants were untreated and treated stripes. Each passage or stripe represented one test plot. In 1983 the field scoring was done on 5 locations of each passage from which 25 plants were evaluated. 50 ears per passage were analysed in the laboratory. In 1984 to 1987 the size of samples for visual assessment amounted to 60 ears per passage. The number of laboratory analyses in 1984 and 1985 was 60 ears per variant and decreased to 30 ears in 1986 and 1987. In all test years the investigations started with the first scoring of the area at ear emergence. Thus, the actual concentration of pests was to be determined, together with the degree of homogenity.

The first directed control measure was taken at DC 52 to 56. In the years 1983 and 1987 methamidophos (Filitox) was applied. The second application was given at the end of flowering (DC 65 to 69). In the years 1983, 1984 and 1986 dimethoate (BI 58 EC) was used. After spraying the field was scored at DC 68 to 70 and DC 75 to 78 to obtain information about the population development of

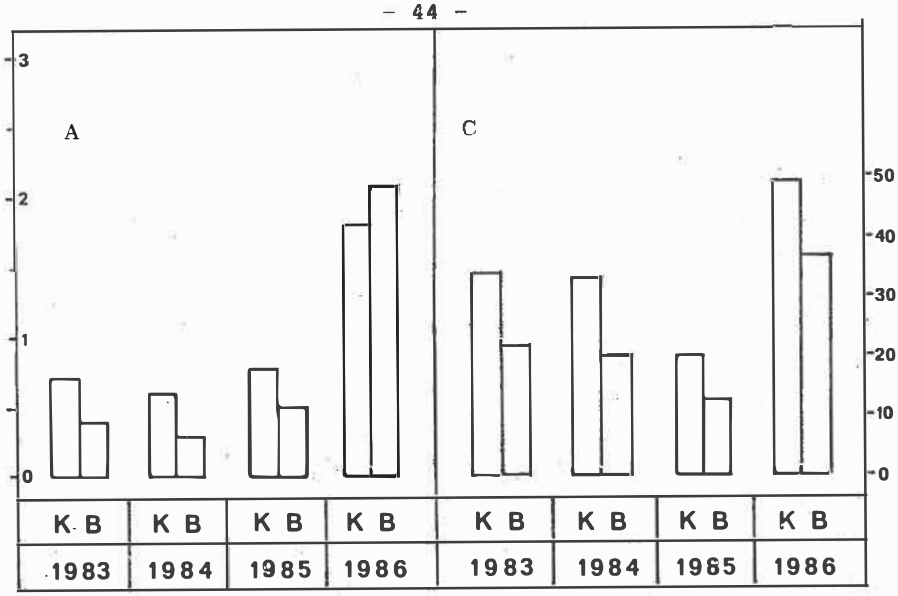


Figure 1 : Contarina tritici : numbers of damaged grains (A) and percentages of infested ears (C) in controls (K) and treated plots by methamidophos (B) at DC 50-56.

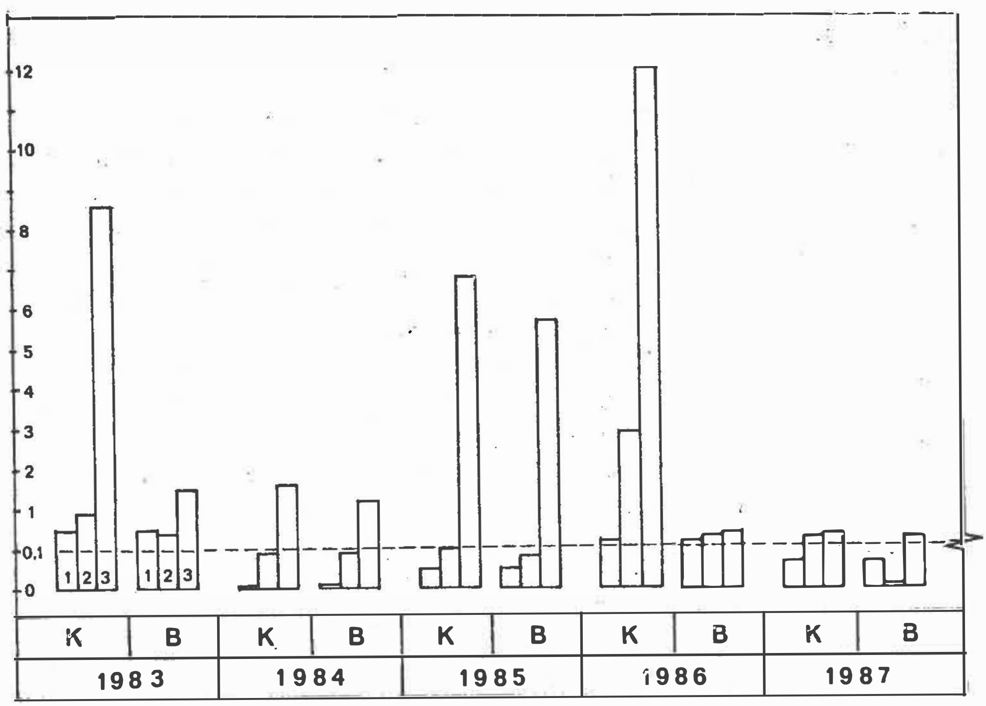


Figure 2 : Sitobion avenae : numbers of aphids/ear for control (K) and treated plots by methamidophos (B) at DC 50-56 (1 - 2 - 3, successive sampling dates).

the ear pests in both variants. The yields of the chemically treated plots were compared with data from other test plots and combine-harvested areas. The statistical evaluation was made on the basis of the variance analysis together with the Maximum-Modulus test.

RESULTS

The first control measure was aimed at studying the possibilities for taking direct influence on the combined incidence of wheat blossom midges and cereal thrips. The best chances for an optimal control of both insects are offered at the beginning of ear emergence.

The results of a 5-year test series allow to state that even when the current threshold values for *Contarinia tritici* (Kirby) were observed, yield losses could not always be avoided.

Therefore we propose to correct the threshold values for control measures against the wheat blossom midge.
Visual examination : 1 ovipositing female per 1 to 3 at DC 51 to 54
Sweep net capturing : more than 50 females per standard capture at DC 51 to 54.
Terms for the abundance assessment : calm warm weather, best time 20 to 21 hour.

As revealed by the data analysis, in the years of 1983 to 1985 the attack by wheat blossom midges was rather low (less than 1 damaged grain per ear) (Fig. 1). Averaging all test years, we recorded an efficiency of 48.0 and 39.3 % respectively for the criteria "damaged grains per ear" and "attacked ears". In 1986 however, we were confronted with the urgency to control wheat midges effectively. The average of 2.1 damaged syncarpies per ear signalized yield losses of about 5 % in view of a general yield potential of 7 t per hectare.

Spraying at the date of ear emergence (DC 55 to 56) did not reduce the number of damaged grains per ear, of larvae per ear and of larvae attacking syncarpies.

Since no data were recorded on the flight dynamics of *C. tritici*, we can suggest that there was no good coincidence between the date of insecticide application and the moment of the main flight of wheat midges. Literature studies have shown that our time of spraying (DC 55 to 56) was too late for preventing the egg-laying of the predominant species *C. tritici* (BASEDOW, 1975 ; LÜBKE, 1982). Another explanation is given by KÖRNER *et al.* (1984). They recommend to apply methamidophos in dry and hot weather in the evening hours with the double quantity of water in order to guarantee an effect of the

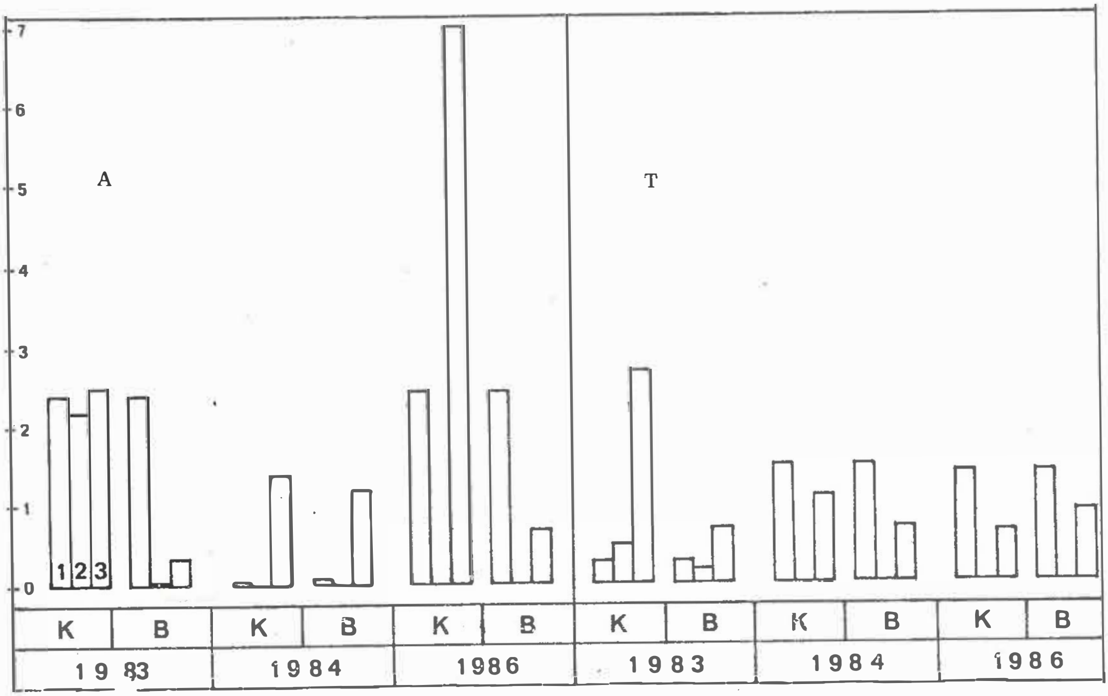


Figure 3 : numbers of aphids (A) and thrips (T) per ear in controls (K) and in treated plots by dimethoate (B) at DC 65-68 (1 - 2 - 3, successive sampling dates).

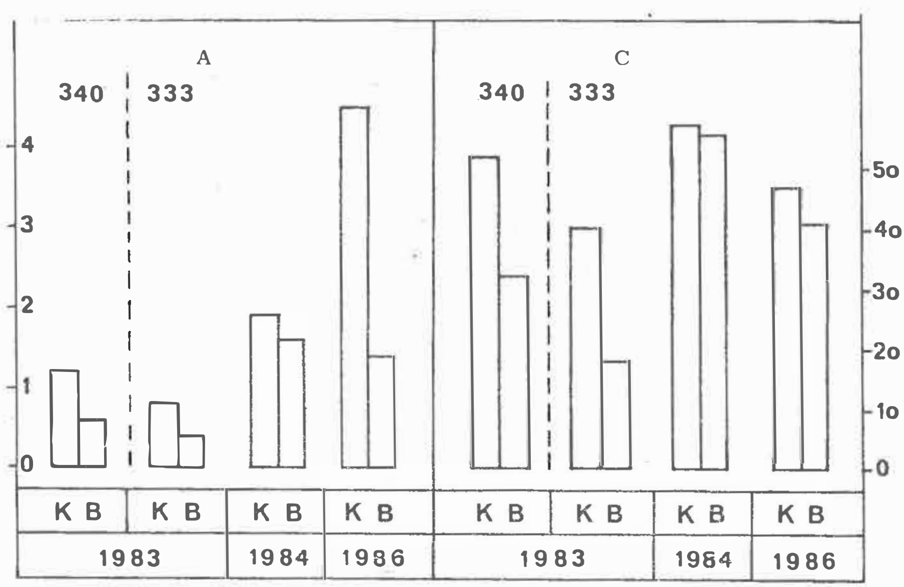


Figure 4 : numbers of damaged grains per ear (A) and percentages of infested ears (C) by Contarina tritici in controls (K) and treated plots by dimethoate (B) at DC 60-65.

treatment. This was not considered when spraying in 1986. The insufficient effect of metamidophos in that year underlines the demand that the question of taking control measures against wheat midges should be decided for each field separately at the beginning of ear emergence with regard to the threshold values.

In all experimental years wheat midges occurred rather poorly (less than 3 insects per ear). A treatment at the beginning of ear emergence helped to reduce the abundance level persistently.

Even in the phase of milky ripeness the mean effect of this application variant was still 34.4 %. Significant yield losses are not provable for the recorded abundance values. In none of the experimental years we had to interfere into the population development of the midges by use of insecticides.

Aphid populations were controlable both in case of low and medium incidence (1983 to 1985 and 1987) as well as under the conditions of gradation (1986), with metamidophos spray at ear emergence (Fig. 2). At the milky ripeness of winter wheat the effect was still 37.2 % averaging the test years. In years with heavy aphid infestation we recorded during the 3rd scoring (DC 73 to 76) an effect of 88.4 % (1983) and 55.8 % (1986). The observed reduction of abundance was in all years sufficient to keep the aphid population below the threshold values.

However, when we regard directed chemical control steps, the mere application of metamidophos to control cereal aphid must be refused because at present it is not possible to give a reliable prognosis on the expected level of incidence at the moment of ear emergence. The analysis of the scoring at DC 50 to 59 over the 5 test years by use of interpretation and decision aids (FREIER *et al.*, 1982) produced clear evidence only for 1984. In that year with and average of 0.01 aphid per plant we susceeded to prevent damage by aphid attack in all cases. The lack of security of a treatment decided at the time of ear emergence is demonstrated by the results obtained for 1983. The data on the attack at DC 50 to 54 signalized a dangerous incidence of aphids under all circumstances (mean 0.5 aphids per ear and standard leaf).

However, the populations developed only to a medium level thanks to unfavourable weather conditions and a high parasitation of the aphids. The data from the 2nd and 3rd scoring revealed that the chemical treatment at the end of wheat flowering could have been omitted if the economic threshold values suggested by WETZEL *et al.*, (1987) had been observed.

In figures 3 and 4 informations are given about the effect of dimethoat on ear pests during the flowering of winter wheat. The influence of a single spray with dimethoate on cereal pests was demonstrated by the average effect of 67.3 % for the three years of experiments. Under the conditions of strong gradation in 1986 the treatment cause an 82.8 % reduction of the infestation. Considering the ears only, the application was successful with 98.9 %. In each year of experimentation cereal aphids were reliably controlled. Abundance levels could be kept below the threshold value until the natural breakdown of the population.

On the untreated passages of the variant dimethoate, thrips were recorded with 3 insects per ear only (Fig. 3). For population density a spraying of dimethoate produced a mean efficiency of 58.2 %. The results confirm that a directed application of dimethoate against aphids involves also a decrease of thrips until they leave the ears by their own.

It was suggested that the use of a systemic insecticide against cereal aphids would have influence also on the larvae of wheat midges in the infested syncarpies. The effect of a single spray on these pests was shown by several relationships.

The mean efficiency for the criterion larvae per ear and damaged grains per ear was 37.2 % and 46.2 %. Thus, under the prevailing conditions of infestation one application was enough to achieve a sufficient reduction of the attack even until the end of flowering.

Yield losses on the treated stripes were less than 5 %. This fact was especially interesting in the year 1986. The necessary spray against aphids reduced also sufficiently the extent of damage caused by midges (variant : 1.4 infested syncarpies per ear), whereas on the untreated stripes the insect population reached values which chemical control (on the average 4.5 damaged grains per ear, Fig. 4). Thus, plant protection experts in practice can choose between two possibilities of effective midge control. When for reasons of time or organisational problems a treatment against *C. tritici* is impossible at the beginning of ear emergence, the larvae population can also be influenced by spraying directly against aphids at the end of wheat flowering. Yet, this requires the application of a systemic agent, since deltamethrine given at DC 59 to 71 did not produce any effect on the hidden midge larvae.

Any ideas to elaborate a combined monitoring and control strategy against ear pests in winter wheat crops are not realistic because the decisions to take direct control measures against wheat midges and cereal aphids have to be made at different times of plant development. If an insecticide is to be applied against

C. tritici after the threshold value is exceeded, it must be made sure on these fields that the spraying against aphids at DC 68 to 71 can be omitted. According to the results obtained (Fig. 2), the application of metamidophos at ear emergence caused a remarkable delay of the aphid propagation. Comprehensive yield analyses were carried out ot investigate the influence of ear pests on the yield characters of winter wheat. The poor infestation by all pests which were studied in 1984, 1985 and 1987 revealed yield differences between treated and untreated stripes of more accidental character. In 1983, however, aphids caused greater damage. Wheat midges and thrips did not occur in such abundances that they had to be controlled. These circumstances elucidated significant yield differences between treated and untreated variants both for a metamodophos application at ear emergence (0.25 t per hectare) and for dimethoate to the wheat flowering (0.23 t).

In 1986 we faced the necessity of spraying against cereal aphids and wheat blossom midges in order to avoid yield losses. Yields from individual plots produced for both dates of application similar yield differences between treated and untreated plots metamidophos 6 %, dimethoate 7 %). For the dimethoate application they could be substantiated statistically on the basis of the single-ear mass.

REFERENCES

BASEDOW Th. 1975. Neues über Biologie und Bekämpfung der Weizengallmücken. *Kali-Briefe* (Büntehof), 12, 1-9.

FREIER B., MATTHES P., WETZEL Th. 1982. Entscheidungshilfen zur kurzfristigen Befallsvorhersage und zur gezielten Bekämpfung der Getreideblattlaus (*Macrosiphum avenae* Fabr.) im Winterweizen. *Nachr.-Bl. Pflanzenschutz DDR*, 36, 192-196.

KÖNER H.J., WIND F., FRITZSCHE R., GEISSLER K. 1984. Erfahrungen und Ergebnisse beim Einsatz von Filitox im Hackfruchtanbau. *Nachr.-Bl. Pflanzenschutz DDR*, 38, 39-42.

LÜBKE M. 1982. Untersuchungen zum Massenwechsel, zur Schadwirkung, Überwachung und Bekämpfung von Weizengallmücken. H*alle-Wittenberg. Martin-Luther-Univ. Diss.* A

WETZEL Th. 1983. Zur Durchsetzung eines integrierten Pflanzenschutzes bei der Bekämpfung wichtiger Schadinsekten des Getreides. *Nachr.-Bl. Pflanzenschutz* DDR, 37, 93-101.

WETZEL Th., HOLZ F., STARK A. 1987. Bedeutung von Nützlingspopulationen bei der Regulation von Schädlingspopulationen im Getreidebestand. *Nachr.-Bl. Dt. Pflanzenschutzd DDR*, 39, 1-7.

WETZEL Th., SPAAR D. 1985. Zum integrierten Pflanzenschutz gegen Schadinsekten des Getreides. *Wiss. Beitr. Martin-Luther-Univ. Halle-Wittenberg, 61*, 51, 14-23.

VARIABILITÉ INTERCLONALE DANS LA PRODUCTION DE FORMES SEXUÉES CHEZ LE PUCERON DES CÉRÉALES *RHOPALOSIPHUM PADI*

J. C. SIMON & C. A. DEDRYVER

INRA, Laboratoire de Recherches de la Chaire de Zoologie de l'ENSAR, Domaine de la Motte, F 35650 LE RHEU

SUMMARY

The aim of this study was to analyse the response of several clones of *Rhopalosiphum padi* L., collected on primary and secondary hosts in Britain and France, submitted to sexual inducing conditions in order to appreciate interclonal variability in *R. padi* populations. Our clones, after sexual morph induction, were caracterized depending on their own life-cycle patterns. As described on *Myzus persicae* Sulz., four types of clonal responses have been found which correspond to holocyclic, anholocyclic, androcyclic and intermediate responses. The local life-cycle strategies of *R. padi* are discussed on the basis of the coexistence of these differents types of clones.

INTRODUCTION

Dans les régions à climat tempéré, les aphides se reproduisent par parthénogénèse cyclique et la phase sexuée annuelle, réalisée généralement à l'automne, est essentiellement induite par l'augmentation de la scotophase, en conjonction, pour certaines espèces, avec la baisse de la température (Lees, 1966 ; Hille Ris Lambers, 1966).

Cependant, à partir de ce schéma reproducteur initial, certains clones voire certaines espèces de pucerons ont perdu partiellement ou totalement la capacité à produire des formes sexuées : les études portant sur des aphides comme *Myzus persicae* Sulz. ou *Aphis gossypii* Glov. et plus particulièrement les travaux de Blackman (1971, 1972, 1974) et de Takada (1988) ont mis en évidence une forte variabilité intraspécifique des modes de reproduction de ces espèces et des types de cycles évolutifs annuels qu'elles sont susceptibles de réaliser.

Tableau 1 : Origines et dates de collecte des clones de *R. padi* soumis à des conditions de photophase courtes et de températures basses.

CLONES	SITES DE COLLECTE	PLANTES-HOTES	DATES
RP LARS	Long Ashton (Avon, G.B.)	*P. padus*	05/87
RP CAEN1	Caen (Calvados, F.)	*P. padus*	05/87
RP RENNES	Rennes (Ille & Vilaine, F.)	*P. padus*	05/87
RP MUR	Mur-de-Bretagne (Côtes d'Armor, F.)	*P. padus*	05/87
RP CAEN2	Caen (Calvados, F.)	*P. padus*	06/88
RP BEAULIEU	Rennes (Ille & Vilaine, F.)	*P. padus*	05/88
RP LEGER	St Léger Vauban (Yonne, F.)	*P. padus*	05/88
RP LE RHEU1	Le Rheu (Ille & Vilaine, F.)	Blé	01/78
RP LE RHEU2	Le Rheu (Ille & Vilaine, F.)	Orge	01/89
RP LE RHEU3	Le Rheu (Ille & Vilaine, F.)	Orge	01/89
RP LE RHEU4	Le Rheu (Ille & Vilaine, F.)	Orge	01/89

Tableau 2 : Nombres moyens (n=5) et écarts-types (entre parenthéses) des différents morphes composant la descendance à 15°C, 10h de photophase, des femelles aptères de 11 clones de *R. padi*.

	MORPHES				
CLONES	EXULES APTERES	EXULES AILES	GYNOPARES	MALES	% DE GYNOPARES
RP LARS	0	0	16.2 (3.4)	18.0 (5.9)	48.4 (5.3)
RP CAEN1	0	0	17.2 (5.9)	10.2 (4.0)	61.4 (13.0)
RP RENNES	0	0	8.6 (1.9)	21.4 (7.8)	31.2 (13.7)
RP MUR	0	0	14.8 (3.5)	15.4 (2.9)	44.4 (4.7)
RP CAEN2	0	0	26.0 (3.5)	12.4 (2.2)	67.6 (5.7)
RP BEAULIEU	0	0	21.2 (1.6)	13.2 (4.0)	62.4 (9.0)
RP LEGER	0	0	23.2 (2.5)	1.0 (1.3)	96.2 (4.7)
RP LE RHEU1	32.0 (7.3)	3.0 (3.0)	0	1.8 (1.2)	-
RP LE RHEU2	52.6 (8.8)	1.6 (2.1)	0	0	-
RP LE RHEU3	41.6 (13.5)	0	0	0	-
RP LE RHEU4	44.2 (10.0)	0.2 (0.4)	0	0.4 (0.5)	-

Dans certaines régions comme l'ouest de la France (Dedryver & Gellé, 1982 ; Dedryver, 1983) et le sud de l'Angleterre (Tatchell *et al*, 1988 ; Hand, 1989), *R. padi* peut réaliser concurremment un holocycle et un anholocycle. Cependant la nature précise des relations entre les populations holocycliques et anholocycliques de cette espèce et les facteurs qui déterminent quelle proportion d'individus d'une population répond aux stimuli de la production des formes sexuées sont encore méconnus.

C'est pourquoi, compte-tenu de l'importance économique de *R. padi*, il nous a paru opportun d'analyser la variabilité des cycles évolutifs dans les populations naturelles de cette espèce d'autant qu'ils semblent jouer un rôle important dans l'épidémiologie de la Jaunisse Nanisante de l'Orge (JNO), lorsqu'elle est étudiée dans une zone géographique donnée (Tatchell *et al.*, 1988 ; Simon *et al.*, 1991).

Nous avons donc soumis, dans cette étude, des clones de *R. padi* d'origines botaniques (hôte primaire et hôtes secondaires) et géographiques (France, Grande Bretagne) diverses à des régimes de courte photophase et de basse température (Dixon & Glen, 1971), afin d'apprécier le mode de reproduction qu'ils développent dans ces conditions expérimentales et de déduire de cette réponse le type de cycle évolutif qu'ils sont susceptibles de réaliser.

MATÉRIEL ET MÉTHODES

Onze clones de *R. padi* dont les origines botaniques, géographiques et les dates de collecte sont mentionnées dans le tableau 1, ont été étudiés.

Ces clones, dont chacun constitue une lignée issue d'un unique descendant, sont maintenus en culture depuis leur récolte dans des conditions de photopériode et de température (18°C, 16h de photophase) assurant la reproduction parthénogénétique continue des pucerons.

Pour chaque clone étudié, cinq larves à ptérothèques de quatrième stade provenant de l'élevage sont exposées à un régime de 15°C, 10h de photophase dans une étuve réfrigérée programmable dispensant une intensité lumineuse d'environ 5000 Lux à 50 cm de la source. Elles composent la première génération (G0) à être stimulée.

La descendance de ces pucerons qui se sont développés en adultes ailés, constitue la génération-fille (G1). Parmi celle-ci, seules cinq femelles (toutes aptères) sont suivies pour chaque clone et maintenues dans les mêmes conditions de photopériode et de température. Tous les descendants de ces femelles aptères (G2) sont isolés quotidiennement et placés individuellement sur une plantule de blé cultivée dans un tube en verre (80 x 10 mm) rempli de gélose et recouvert d'une microcage en polystyrène cristal (140 x 16 mm). Le morphe de

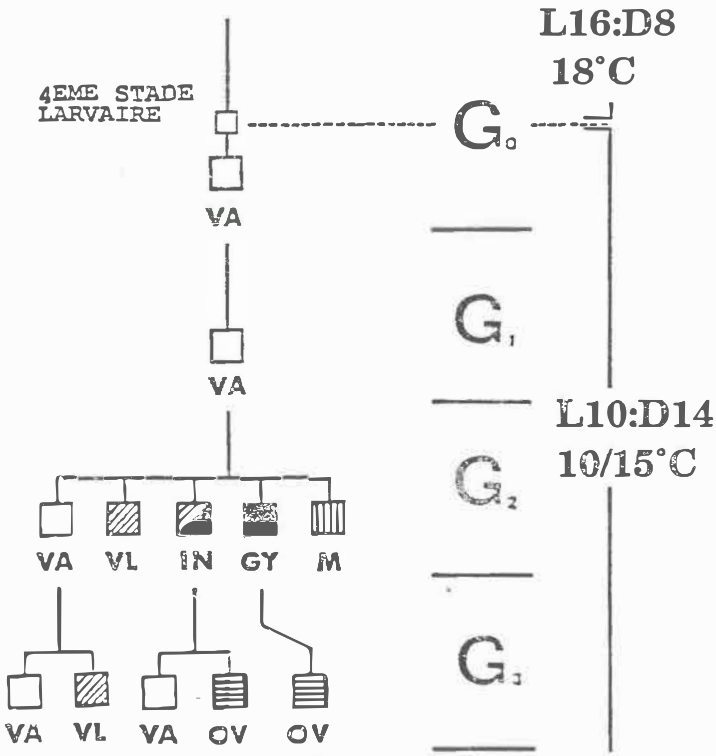


Figure 1 : Modes de reproduction réalisés par *R. padi* : VA = virginipare aptère, VL = virginipare ailé, IN = intermorphe, M = mâle et OV = ovipare.

chacun d'entre eux est identifié au stade adulte. Un test de choix entre une feuille de *P. padus* et une feuille de blé permet de différencier les femelles ailées obtenues en G2.

Dans le cas des clones RP LE RHEU2, RP LE RHEU3, et RP LE RHEU4, la troisième génération après l'induction (G3) est également analysée de la même manière que la deuxième génération (G2).

Ces trois clones sont par ailleurs soumis à un second régime de température et de photopériode de 10°C, 10h de photophase et suivis pendant deux générations (G1 et G2) selon le protocole exposé ci-dessus.

RÉSULTATS

- Le nombre moyen des différents morphes composant la descendance en G2 de cinq femelles exposée à 15°C, 10 h de photophase est indiqué pour chaque clone dans le tableau 2.

Tous les clones collectés sur *P. padus* présentent une réponse **holocyclique** qui se caractérise par un processus de reproduction comprenant deux phases successives ; la production de gynopares puis celle de mâles. Le pourcentage de gynopares dans la descendance peut varier considérablement selon les clones (tableau 2), de 31 % pour RP RENNES à 96 % pour RP LEGER, mais il varie également entre les individus d'un même clone. C'est ainsi que par exemple trois des cinq parents de RP LEGER ne produisent que des gynopares et aucun mâle dans leur descendance de première génération.

Deux clones collectés sur graminées, RP LE RHEU2 et RP LE RHEU3 présentent une réponse **anholocyclique**. Celle-ci présente deux caractéristiques :

- i) aucun des individus dont on a suivi la descendance en G2 (pour cinq parents) puis en G3 (pour trois parents) ne produit de gynopares ou de mâles, ils forment seulement des exules aptères (RP LE RHEU3) ou un mélange d'exules aptères et de quelques ailés (RP LE RHEU2) ;

- ii) la fécondité totale des individus de ces deux clones est significativement plus élevée que celle des parents de tous les autres clones (tableau 2) ($P < 0.05$, test de comparaison de moyennes Newman-Keuls).

Les deux autres clones collectés sur graminées, RP LE RHEU1 et RP LE RHEU4 présentent une réponse **androcyclique** : ils forment des femelles parthénogénétiques, essentiellement des exules aptères, mais également quelques mâles (beaucoup moins que les clones holocycliques) en fin de période de reproduction. Cette réponse androcyclique n'est pas toujours exprimée par la totalité des individus testés pour un clone donné : ainsi chez le clone RP LE RHEU1, quatre femelles sur les cinq testées sont andropares et seulement deux femelles sur cinq ont donné des mâles en G2 chez le clone RP LE RHEU4. Toutefois, pour ce dernier clone, la production de mâles est renforcée en G3 : non seulement le nombre de mâles formés par femelle est plus important (trois mâles par parent en moyenne en G3 contre un en G2) mais tous les individus testés forment des mâles.

D'une manière générale la production de mâles débute plus tardivement chez les clones androcycliques que chez les clones holocycliques.

- A 10°C, 10 h de photophase la réponse des clones RP LE RHEU2 et RP LE RHEU3 est anholocyclique et celle de RP LE RHEU1 androcyclique, comme à 15°C, 10 h de photophase. Par contre le clone RP LE RHEU4 présente un type de réponse original : les cinq individus de la G1 analysés forment en premier lieu en G2 de nombreux exules aptères en mélange avec quelques femelles ailées, puis en second lieu des mâles.

Ces femelles ailées, soumises à un test de choix entre blé et *P. padus*, se révèlent appartenir à deux catégories : la première est constituée d'exules qui s'installent et se reproduisent uniquement sur blé après 72 heures d'observation, la seconde est composée d'individus qui, après le même délai, produisent des exules aptères sur blé mais également des femelles ovipares sur *P. padus*, ces dernières étant cependant en nombre plus restreint. Cette catégorie de pucerons ailés constitue une forme intermédiaire, ou **intermorphe**, entre exule ailé et gynopare. Le nombre d'intermorphes et de mâles est faible puisqu'il représente respectivement 6.5 % et 7.0 % de la descendance cumulée des cinq parents.

La figure 1 résume les différents morphes susceptibles d'être formés par *R. padi* en fonction du clone, du type d'induction et de la génération.

DISCUSSION - CONCLUSION

Quatre types de réponse à des conditions de photopériode et de température connues pour induire la production de gynopares et de mâles chez *R. padi* (Dixon & Glen, 1971) ont été obtenues après l'analyse de la descendance de onze clones de cette espèce. Ces types de réponse sont très proches de ceux qui ont été précédemment décrits chez *A. gossypii* (Takada, 1988) et chez *M. persicae* (Blackman, 1971, 1972).

Les réponses holocycliques que nous avons observées sont globalement semblables à celle détaillée par Dixon & Glen (1971), c'est à dire strictes : seuls des gynopares et des mâles sont produits. Cependant, notre échantillon de clones prélevés sur hôte primaire est trop faible pour qu'on puisse affirmer qu'il n'existe pas, chez cette espèce, de clones développant des réponses holocycliques partielles, telles que celles observées par Blackman (1971) chez *M. persicae* et par Hand & Wratten (1985) ainsi que Wegorek & Dedryver (1987) chez *Sitobion avenae* F..

La réponse anholocyclique exprimée par deux clones (RP LE RHEU2 et RP LE RHEU3), collectés sur céréales en hiver ne semble pas varier en fonction des conditions d'induction puisqu'elle est stable selon la température et le nombre de générations, tout au moins dans les limites de notre étude.

Nous confirmons ainsi qu'il paraît exister, dans l'ouest de la France, des clones de *R. padi* ayant perdu toutes capacités à former des sexués (Dedryver & Gellé, 1982).

Par ailleurs, la fécondité totale des clones anholocycliques de *R. padi* est, dans des conditions inductrices de la phase sexuée, très supérieure à celle des clones holocycliques et androcycliques. De tels résultats ont également été obtenus par Newton & Dixon (1988) sur *S. avenae*.

Deux autres clones (RP LE RHEU1 et RP LE RHEU4), collectés également sur céréales en hiver, ont développé une réponse androcyclique. Comme chez *M. persicae* (Blackman, 1971), les clones androcycliques de *R. padi* testés se caractérisent par une production de mâles plus faible que celle des clones holocycliques, certains individus de ce type de clone pouvant ne pas exprimer leur capacité à former ce morphe.

Cette caractéristique donne à penser qu'en plus de la perte de l'aptitude à produire des gynopares, ces clones voient affecter leur mécanisme de production des mâles (induction maternelle, déterminisme chromosomique du sexe).

Le clone RP LE RHEU4 présente, après une stimulation à 10°C, 10 h de photophase, une réponse particulière caractérisée par la production de mâles et d'une forme intermédiaire entre gynopare et exule ailé. Cet intermorphe de *R. padi* a été trouvé sur le terrain et décrit par Tatchell & Parker (1990) en Grande Bretagne. Sa nature est différente de celle des morphes intermédiaires obtenus expérimentalement pour des conditions d'induction-seuil (Crema, 1971). Seule l'étude de son comportement pourrait nous renseigner sur ces capacités réelles à se reproduire sur graminées puis à regagner un hôte primaire pour y donner naissance à des ovipares.

Si l'on s'intéresse plus particulièrement aux clones récoltés dans les environs du Rheu (3 holocycliques, 2 anholocycliques et 2 androcycliques), on voit que les populations de *R. padi* y sont susceptibles d'être composées à certaines périodes de l'année d'un mélange de clones pouvant réaliser des cycles évolutifs différents.

Les bases de la coexistence entre ces diverses catégories clonales paraissent essentiellement fonction du climat hivernal, qui permet ou non la survie des fractions parthénogénétiques, et de la fréquence de l'hôte primaire dont la rareté en Bretagne limite probablement l'importance de la fraction holocyclique locale au printemps.

Deux hypothèses non exclusives permettent d'expliquer le maintien local à long terme des populations composées des différents types de clones : d'une part leur renforcement périodique par des apports d'individus ailés exogènes, d'autre part la possibilité qu'auraient les mâles issus de clones androcycliques de participer à la reproduction sexuée ce qui constituerait une sauvegarde de populations à potentialités anholocycliques (Blackman, 1972).

BIBLIOGRAPHIE

BLACKMAN, R. L., 1971. Variation in the photoperiodic response within natural populations of *Myzus persicae* Sulz.. Bull. Ent. Res. 60 : 533-546.

BLACKMAN, R. L., 1972. The inheritance of life-cycle differences in *Myzus persicae* (Sulz.) (Hem., Aphididae). Bull. Ent. Res. 62 : 281-294.

BLACKMAN, R. L., 1974. Life-cycle variation of *Myzus persicae* (Sulz.) (Hom., Aphididae) in different parts of the world, in relation to genotype and environment. Bull. Ent. Res. 63 : 595-607.

CREMA, R., 1971. Changes in the ovary of *Acyrthosiphon pisum* Harris during transition from amphigony to parthenogenesis. Monitore Zool. Ital. 5 : 81-90.

DEDRYVER, C. A., 1983. Evolution des populations de *Rhopalosiphum padi* L. sur son hôte primaire, *Prunus padus* L. dans deux stations du nord et de l'ouest de la France. Agronomie 3 : 1-8.

DEDRYVER, C. A. & A. GELLE, 1982. Biologie des pucerons des céréales dans l'ouest de la France. IV - Etude de l'hivernation de populations anholocycliques de *Rhopalosiphum padi* L., *Metopolophium dirhodum* Wlk. et *Sitobion avenae* F. sur repousses de céréales, dans trois stations de Bretagne et du Bassin Parisien. Acta Oecologica. Oecol. Applic. 3 : 321-342.

DIXON, A. F. G. & D. M. GLEN, 1971. Morph determination in the bird cherry-oat aphid, *Rhopalosiphum padi* L. Ann. appl. Biol. 68 : 11-21.

HAND, S. C., 1989. The overwintering of cereal aphids on Gramineae in southern England, 1977-1980. Ann. appl. Biol. 115 : 17-29.

HAND, S. C. & S. D. WRATTEN, 1985. Production of sexual morphs by the monoecious cereal aphid *Sitobion avenae*. Entomol. exp. appl. 38 : 239-247.

HILLE RIS LAMBERS, D., 1966. Polymorphism in Aphididae. Ann. Rev. Ent. 11 : 47-78.

LEES, A. D., 1966. The control of polymorphism in Aphids. Adv. Ins. Physiol. 3 : 207-277.

NEWTON, C. & A. F. G. DIXON, 1988. A preliminary study of variation and inheritance of life-history traits and the occurence of hybrid vigour in *Sitobion avenae* (F.) (Hemiptera : Aphididae). Bull. ent. Res. 78 : 75-83.

SIMON, J. C., C. A. DEDRYVER, J. S. PIERRE, 1991. Identifying bird cherry-oat aphid *Rhopalosiphum padi* emigrants, alate axules and gynoparae : application of multivariate methods to morphometric and anatomical features. Entomol. exp. appl. (à paraître).

TAKADA, H., 1988. Interclonal variation in the photoperiodic response for sexual morph production of Japanese *Aphis gossypii* Glover (Hom., Aphididae). J. appl. Ent. 106 : 188-197.

TATCHELL, G. M., R. T. PLUMB & N. CARTER, 1988. Migration of alate morphs of the bird cherry aphid (*Rhopalosiphum padi*) and implications for the epidemiology of barley yellow dwarf virus. Ann. appl. Biol. 112 : 1-11.

TATCHELL, G. M. & S. J. PARKER, 1990. Host plant selection by migrant *Rhopalosiphum padi* in autumn and the occurence of an intermediate morph. Entomol. exp. appl. 54 : 237-244.

WEGOREK, P. & C. A. DEDRYVER, 1987. Action de la température et de la photopériode sur la production de formes sexuées par différents clones du puceron des céréales *Sitobion avenae*. Entomol. exp. appl. 45 : 89-97.

Reasons for and consequences of the serious BYDV infestation in Northern Germany 1989

C. Borgemeister[1] and H.-M. Poehling[2]
[1] Institut für Pflanzenkrankheiten und Pflanzenschutz der Universität Hannover, Herrenhäuser Str. 2, D-3000 Hannover 21, FRG
[2] Institut für Pflanzenpathologie und Pflanzenschutz der Universität Göttingen, Grisebachstr. 6, D-3400 Göttingen, FRG

Summary
In 1988/89 the first heavy BYDV outbreak in the FRG was recorded. Damages occured mainly in winter wheat. Figures of a reduction of wheat yields up to 40% were recorded. The epidemic was mainly caused by an early spring immigration of *Sitobion avenae,* the predominant aphid vector in Northern Germany. The heavy yield losses were probably not only due to the virus disease but also to dry wheather conditions in May and June 1989. The necessesity of a specific forecast system for the regional circumstances in Northern Germany is discussed.

1.1 Introduction

In the past the barley yellow dwarf virus (BYDV) has never been of great concern for the production of cereals in the Federal Republic of Germany. Although cereal aphids, the vector of the disease, are the most important economic pest, especially in winter wheat (BASEDOW 1976), the proportion of virus infected plants rarely exceeded a rate of 1% (HUTH 1990). The last heavy outbreak of BYDV occured 1977 in some regions of Schleswig-Holstein (JUNGA 1989). The major BYDV infection in Northern Germany 1988/89 has now initialized an intensive discussion in the FRG whether this disease could become a permanent problem in the future. Unfortunately the 1988/89 epidemic was not accompanied by any scientific investigations so in this paper we can only describe the present situation in Northern Germany.

1.2 General outlook

The main reason for last years heavy aphid- and BYDV outbreak was probably the mild autumn in 1988, which enabled an unusual long lasting aphid flight and the extraordinary warm winter and spring in 1988/89 (figure 1). Because of the high temperatures during the winter months a great part of the anholocyclic aphid clones survived this period. Although anholocycly, especially in the case of *Sitobion avenae* (F.) (Homoptera: Aphididae), the most important aphid species in Northern Germany, can even be found in the very north of Germany (HÖLLER 1990) these clones usually show a high degree of mortality caused by the normal frost periods. Additionally the outreageous warm period in March 1989 allowed an extraordinary early hatching of holocyclic *S. avenae* clones and a fast establishment of the aphids in winter cereals. Taking into account the time when the first distinct symptoms were visible in the fields, i.e. the late April and the beginning of May 1989, it is obvious that the main infection in the case of winter wheat was set during the early spring 1989.

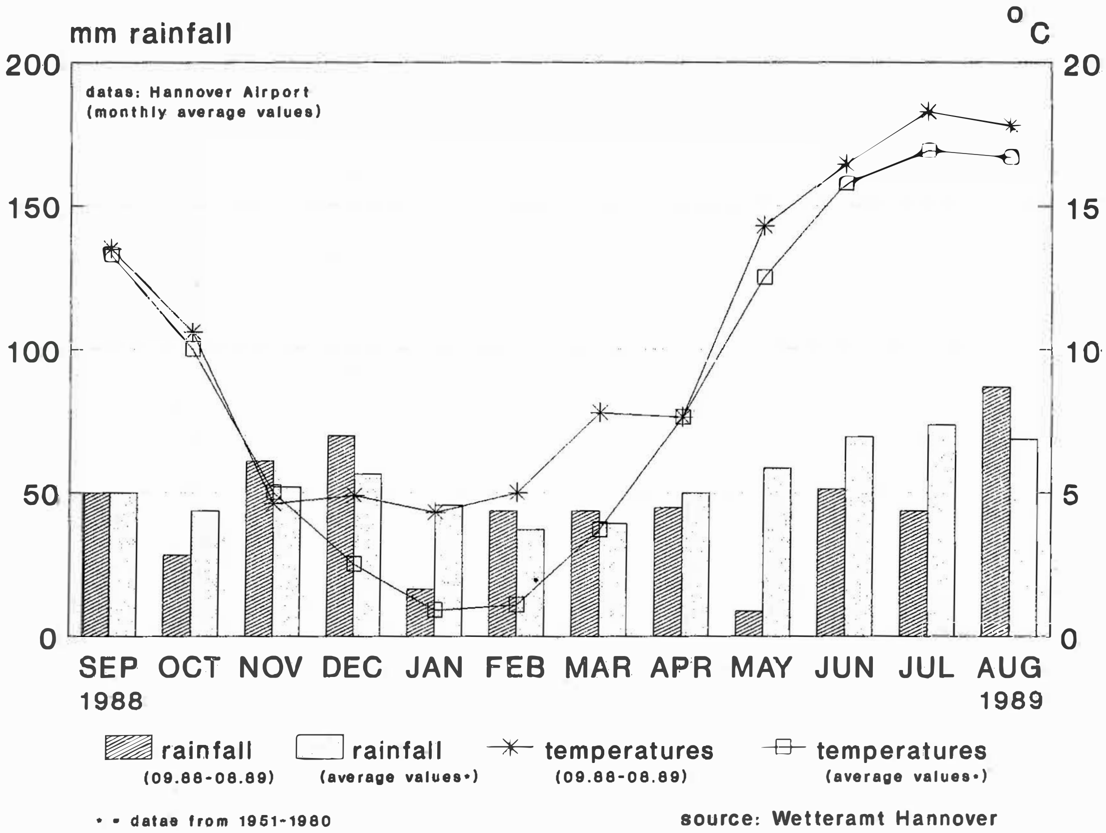
The 1988 autumn infection of winter barley produced only minor damages. BYDV infected barley reacts very sensible to minus degrees (HUTH 1990) and in this sense the mild winter 1988/89 tempered the threat of the disease. The spring aphids, in their majority *S. avenae*, partly originating from wild grasses and pasture, were therefore probably the predominant virus vectors.

HUTH (1990) could detect PAV-, MAV-, and RPV-strains of BYDV in several common wild gras species in the FRG, like *Lolium perenne*, *Bromus saecalinus*, *Bromus sterilis*, *Dactylis glomerata* and *Agropyron repens* and regards them beside maize as the most important sources of the virus.

Figure 2 shows the population trends of cereal aphids in three different locations in the region of Göttingen/Lower-Saxony. Compared with other years the aphid development shifted at least four to six weeks in advance (POEHLING). Empirically the current West German threshold of 20% aphid infested wheat stems (BASEDOW et al. 1983) is reached in the northern part of Germany during the second half of June. Dry wheather conditions at the end of June 1989 which caused a premature ripening of the wheat and high densities of aphid specific predators, in their majority Coccinellids, produced an early break-down of the aphid population.

The average wheat yields in 1989 were drastically reduced. In certain regions figures of a reduction up to 40% of yields were reported (BARTELS & WINTGEN 1990). The danger of an early BYDV infection in April and May 1989 was neither recognized by the advisory boards nor by the farmers. Taking into consideration the few cases of BYDV in former years in Germany simply none expected the wheat yields to be influenced in such a manner. Consequently the aphids were mainly regarded as a direct damaging pest than as a virus vector. In this sense not all insecticide treatments, especially the late ones, obtained sufficient results. Concerning last years experiences late applications in this context were even those which were

FIGURE 1 Meteorological Values: September 1988 - August 1989



lead through around ear emergence (EC 55). In regular years an insecticide treatment at this stage is rather regarded as a prophylactic procedure.
Figure 3 shows the effects of different timed Fenvalerate applications on yield and the frequency of observed BYDV related symptoms (expressed by the not unequivocal term "black ears"). Concerning the levels of aphid infestation the two insecticide plots can not be directly compared because the datas only reflect the situation on the 19th of June 1989, three days after the late Fenvalerate spraying. The early treated plots had higher yield values and showed fewer BYDV related symptoms. This corresponds with observations from regions with routine Deltamethrin applications in EC 49 against saddle gall midges (BARTELS & WINTGEN 1990). In contrast to these results there are reports of multiple treatments with Demeton-s-methyl that had little effect on the yield level (HUTH 1990). In general no insecticide application can absolutely prevent a primary BYDV infection, especially if the vector population like in 1988/89 immigrates over longer period into the fields.

Without denying the obvious BYDV infection in 1988/89 it is not possible to quantify exactly the damage caused by the virus alone. What made the situation in 1988/89 so severe was more an interplay of several components. In this connection the extreme drought in May and June 1989 certainly plays a central role. It is well known from the epidemiology of fungus diseases that a second stress factor like water stress can aggravate the damages for the host plant (OERKE & SCHÖNBECK 1986). Additionally the heavy aphid pressure alone was good enough for a severe reduction of the cereal yields.
Beside the red flag leafs the most commonly observed symptom which were brought into connection with the virus were, as mentioned before, the darkish discoloured wheat ears. The main cause for that were secondary infections with saprophytic sooty noulds. On the other hand these fungi not only settle on virus infected plant but also on honeydew excretions as a consequence of heavy aphid infestation (RABBINGE & MANTEL 1981). An ELISA screening of 56 wheat ears exhibiting these symptoms revealed that at least 27% were free of any virus or the virus content was below the limits of the testing method (HUTH 1990).
Summarizing all these observations it is unlikely that all yield deficits were solely caused by the BYDV infection. Therefore it seems admissible to postulate that the extraordinary drought in May and June 1989 worsened the situation to a large extent and that it is not possible at the present to relate the observed damage to certain factors.
It also seems to be precipitate to draw general conclusions, i.e. prophylactic insecticiede treatments or the ad

FIGURE 2 Aphid densities 1989
(three locations in Lower Saxony - FRG)

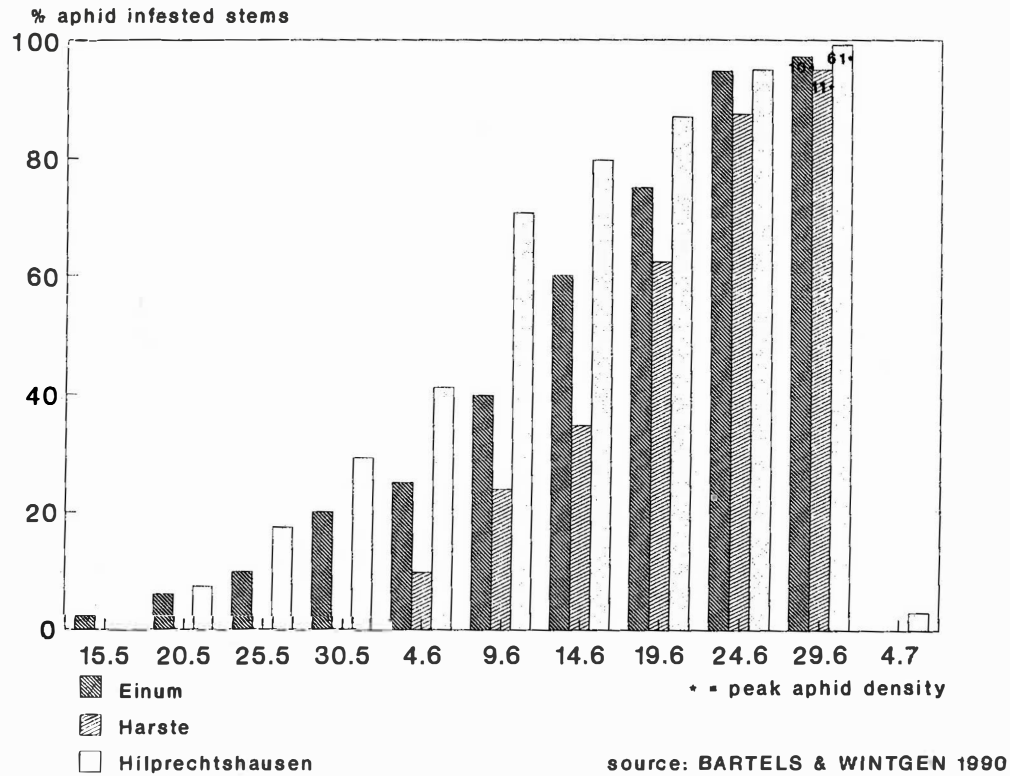
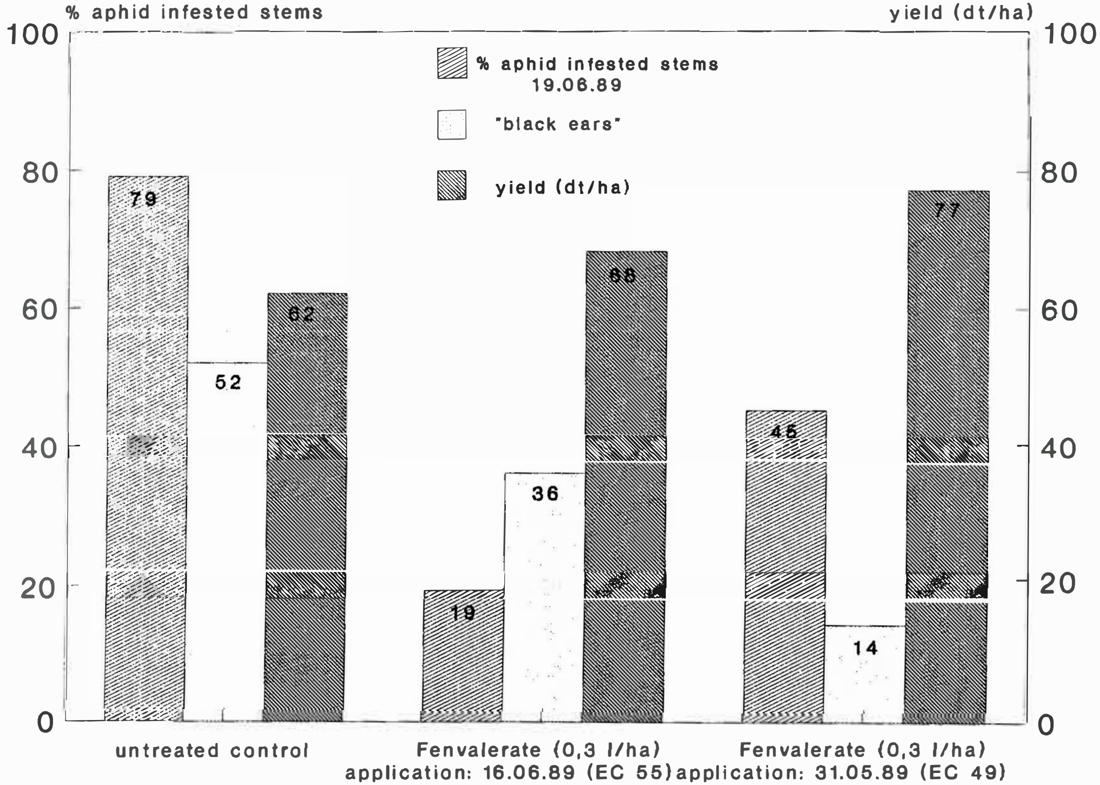


FIGURE 3 Effects of two Fenvalerate treatments on the population density of cereal aphids, yield and "black ears" Einum (FRG) 1989



source: BARTELS & WINTGEN 1990

hoc establishment of distinct thresholds, from the experiences of only one year with a major infection. An intensification of the research on BYDV for the specific situation in Northern Germany with the aim to elaborate an economic threshold for these circumstances should be the right answer. Scientific data of the BYDV epidemiology and the overwintering strategies of the vector population for Germany are very scarce. Therefore it is the duty of scientific research to fill these gaps so that substantial advices can be given to the farmers as soon as possible. In the meantime only intensive monitoring of the aphid development plus routine ELISA testings in the threatened regions may help to contain the prophylactic use of insecticides with all their detremental consequences for the whole ecosystem.

REFERENCES

1. Bartels, M. and Wintgen A. (1990): Gerstengelbverzwergungsvirus - Eine neue Gefahr für den Weizen. PSP (in press)

2. Basedow, T. (1976): Über das Auftreten der Getreideblattlausarten (Hom., Aphididae) in norddeutschen Weizenanbaugebieten (1974/75). Anz. Schädlingskde., Pflanzenschutz, Umweltschutz. 49, 9-14

3. Basedow, T., Bauers, C. and Lauenstein, G. (1983): Zur Bekämpfungsschwelle der Getreideblattläuse an Winterweizen (vorläufige Mitteilung). Nachrichtenbl. Deut. Pflanzenschutzd. 35, 141-142

4. Höller, C. (1990): Overwintering and hymenopterous parasitism in autumn of the cereal aphid Sitobion avenae (F.) in northern FR Germany. J. Appl. Ent. 109, 21-28

5. Huth, W. (1990): Barley yellow dwarf - ein permanentes Problem in der Bundesrepublik Deutschland? Nachrichtbl. Deut. Pflanzenschutzd. 42 (3), 33-39

6. Junga, U. (1989): Gelbverzwergungsvirus der Gerste in Winterweizen. Bauernblatt/Landpost 8, 28-32

7. Oerke, E.-C. and Schönbeck, F. (1986): Zum Einfluß abiotischer Streßfaktoren auf das Wachstum von Gerste und Bohne und deren Prädisposition gegenüber Schaderregern. Z. Pfl.Krankh. u. Pfl.Schutz 93 (6), 561-573

8. Poehling, H.-M. (1988): Influence of cereal aphid control on aphid specific predators in winter wheat (Homoptera: Aphididae). Entomol. Gener. 13 (3/4), 163-174

9. Rabbinge, R. and Mantel, P. (1981): Monitoring for cereal aphids in winter wheat. Neth. J. Pl. Path. 87, 25-29

DYNAMIQUE DES VECTEURS ET DES VIRUS DE LA JAUNISSE NANISANTE DE L'ORGE DANS LE BASSIN DE RENNES A L'AUTOMNE 1989

Françoise LECLERCQ-LE QUILLEC & C.A. DEDRYVER

INRA, Laboratoire de Recherches de la Chaire de Zoologie de l'ENSAR, Domaine de la Motte, F 35650 LE RHEU

SUMMARY

Cereal aphids were caught alive by a special suction trap in Le Rheu during the autumn 1989 and allowed to transmit BYDV on test plants (oat, cv Blenda). BYDV strains were identified by ELISA procedure using monoclonal antibodies. Only *Rhopalosiphum padi* L. alates were caught from September to November ; 35.4 % were infectious and transmitted PAV and RPV alone or in mixture, and MAV in mixed infections with other strains. The percentages of each strain in the pooled transmission tests were rather similar to the percentages of each strain in an infected barley sample collected in an adjacent field at the same period.

Les régions de l'Ouest de la France sont particulièrement sujettes aux épidémies de Jaunisse nanisante de l'orge (J.N.O. ou B.Y.D.), du fait de leurs caractéristiques écoclimatiques. Les automnes et hivers généralement doux y permettent une multiplication importante des pucerons vecteurs sur certains réservoirs, en particulier le maïs (HENRY & DEDRYVER, 1989), puis le maintien, voire le développement, de populations aphidiennes anholocycliques sur l'orge et le blé au cours de l'hiver (LECLERCQ-LE QUILLEC & DEDRYVER, 1990). De ce fait les infections primaires des jeunes céréales sont souvent massives et la dissémination secondaire des virus importante. Plus généralement, la succession annuelle de différentes cultures de graminées multiplicatrices de virus et de pucerons (céréales à pailles-maïs) ainsi que l'abondance de réservoirs permanents et pérennes comme les graminées fourragères (HENRY & DEDRYVER, 1991), n'y permettent généralement pas de rupture de l'association virus-vecteurs-plantes au cours de l'année.

Dans ces régions, la prévision des risques encourus à l'automne par les jeunes semis de céréales peut être faite sur la base des captures de pucerons des céréales au piège à succion de 12.2 m de haut (type Rothamsted) du réseau AGRAPHID (ROBERT & CHOPPIN DE JANVRY, 1977 ; HULLE & GAMON, 1989). Il existe en effet une relation particulièrement stable entre les captures hebdomadaires du principal vecteur, *Rhopalosiphum padi* L. et les taux d'infestation de plants d'orge "pièges" disposés au champ et renouvelés chaque semaine (GILLET *et al.*, 1990). Cette relation permet dès à présent de simuler, avec un pas de temps d'une semaine, les risques d'infestation des cultures par les pucerons.

Cependant la prévision des risques d'infection virale correspondants nécessite une pondération des résultats précédents par le pouvoir virulifère des pucerons. Celui-ci est jusqu'ici estimé indirectement, par détection en ELISA des virus de la J.N.O. dans les plants d'orge "pièges" précédemment mentionnés (PIERRE *et al.*, 1987).

Afin de simplifier les méthodes expérimentales et de raccourcir les délais d'estimation des risques, on peut envisager de tester le caractère virulifère de pucerons capturés vivants (ce qui est impossible avec le piège de 12.2 m) à l'aide d'un piège spécialement adapté. Ceci peut se faire directement, en détectant en ELISA la présence de virus dans les pucerons capturés (TORRANCE, 1987) ; ou indirectement par l'intermédiaire de plantes-tests (PLUMB, 1976 ; A'BROOK & DEWAR, 1980).

La première méthode étant encore en voie de mise au point, nous exposons dans cet article une application de la seconde. La dynamique des pucerons piégés et des isolats qu'ils ont transmis y est comparée à celle des pucerons et des virus dans un champ d'orge au cours de la même période (automne 1989).

MATERIELS & METHODES

Au cours de l'automne 1989 les pucerons ailés en déplacement aérien sont capturés journellement à l'aide d'un piège à succion spécialement adapté à la récolte des insectes vivants, d'un modèle analogue à celui fonctionnant au Rothamsted Insect Survey à Harpenden (PLUMB, 1976). Ce piège mesure 1,5 m de haut. Il est muni d'un ventilateur hélicoïde de 450 mm de diamètre débitant environ 3000 m^3 d'air à l'heure. Le piège est placé dans le parc météorologique de l'INRA au Rheu, à proximité du piège à succion de 12,2 m du réseau AGRAPHID, dans une zone de grandes cultures. Pour des raisons liées à la survie des pucerons capturés, le piège ne fonctionne que 5 jours par semaine, de 9 h à 16 h.

Les espèces d'aphides piégées dans la journée sont identifiées puis les pucerons inféodés aux céréales sont installés individuellement sur des plantules d'avoine (cv. Blenda) qui sont ensuite entreposées à 18°C, 16 h de photophase pendant 5 jours afin d'assurer une éventuelle transmission virale. Ces plantules sont ensuite traitées à la deltamethrine (Décis à 0.5 ml/l) puis placées en serre à l'abri des contaminations de pucerons pendant 15 jours. Les plantules sont finalement testées en ELISA comme ci-dessous.

Une parcelle d'orge d'hiver (cv. Express) située à quelques centaines de mètres du piège, semée le 13 septembre 1989, fait l'objet d'un échantillonnage bi-hebdomadaire de fin septembre à fin décembre. A chaque date d'échantillonnage 360 plants d'orge sont prélevés dans la parcelle, par groupe de 30 plantes consécutives. Les pucerons qui s'y trouvent sont déterminés au champ d'après des critères d'observation macroscopiques et les plantules sont ensuite testées individuellement en ELISA en vue de la détection des différents virus présents.

Pour les 2 expérimentations, la détection des virus transmis est réalisée en ELISA indirect à 2 sites, utilisant comme capteurs des sérums polyclonaux : PcB de Bioreba (Bâle, Suisse) ; Pc PAV, Pc MAV et Pc RPV fournis par H. LAPIERRE (INRA, laboratoire de virologie, CNRA Versailles). Trois anticorps monoclonaux, MAC 91, MAC 92 et MAFF2 du MAFF (Ministry of Agriculture Fisheries and Food, Harpenden, Grande Bretagne) sont employés, comme révélateurs des virus PAV, RPV et MAV (ROCHOW, 1970).

RESULTATS

R. padi est la seule espèce de pucerons des céréales capturée par le piège de 1,5 m entre septembre et novembre 1989. Dans le même temps cette espèce constituait 97,2 % des captures de pucerons des céréales au piège de 12,2 m, contre 2,2 % pour *Sitobion avenae* F. et 0,3 % pour *Metopolophium dirhodum* Wlk. La figure 1 indique que c'est en septembre que le pourcentage de *R. padi* ayant transmis des isolats viraux est le plus important (62,5 %). Il n'est plus que de 25 % en octobre. En novembre aucun *R. padi* virulifère n'est capturé.

Parmi les 23 *R. padi* virulifères capturés, 13 (56,5 %) ont uniquement transmis des isolats de type PAV, 2 (8,7 %) ont transmis uniquement des isolats de type RPV et aucun ne transmet d'isolat MAV pur. Cependant 8 pucerons ont transmis des isolats MAV en association avec une ou plusieurs autres souches virales : 4 avec RPV, 2 avec PAV et 2 avec PAV et RPV.

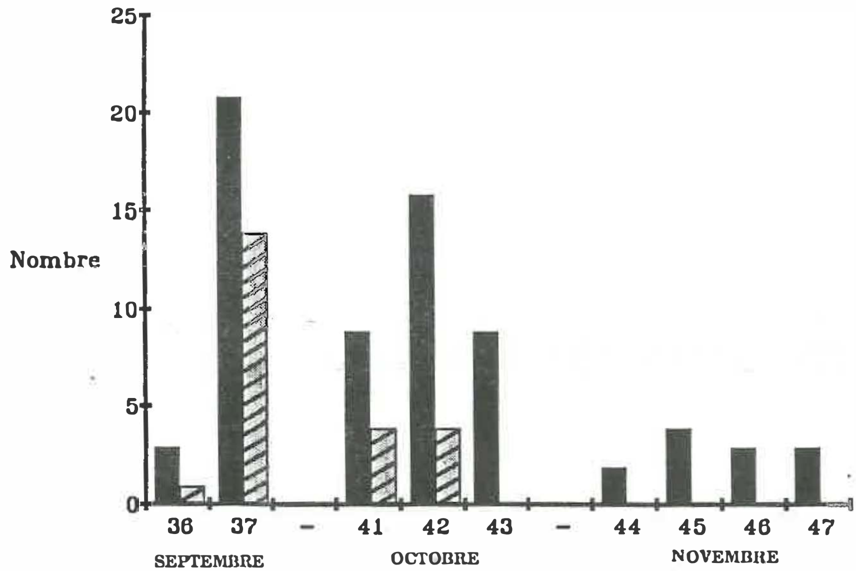


Figure 1 : Nombre de *R. padi* (■) et nombre de *R. padi* virulifères (▨) capturés à 1,5 m au cours de l'automne 1989

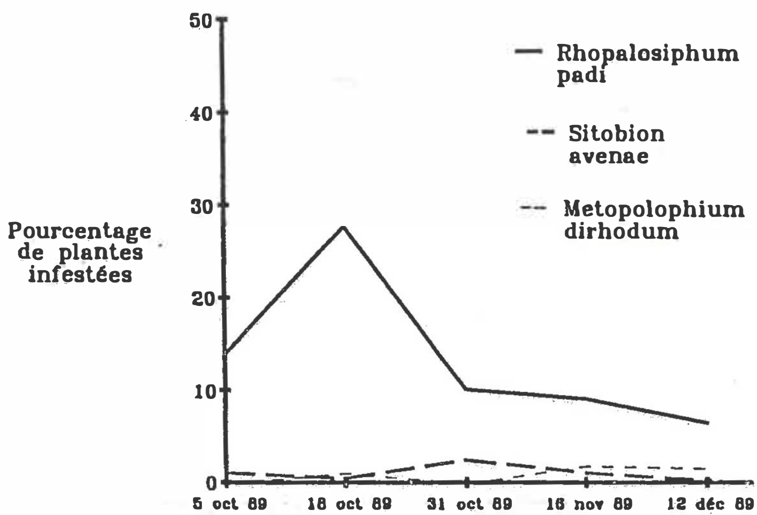


Figure 2 : Infestation de la parcelle d'orge par les différentes espèces de pucerons des céréales au cours de l'automne 1989.

La colonisation de la parcelle d'orge est représentée Figure 2. L'espèce *R. padi* colonise jusqu'à 28 % des plantes le 18/10 puis le pourcentage de plantes colonisées régresse pour se stabiliser autour de 10 % entre fin octobre et début décembre. *S. avenae* et *M. dirhodum* colonisent chacun moins de 2 % des plantes au cours de cette période.

Les fréquences respectives de chaque souche ou virus dans les deux types d'échantillons récoltés sont assez comparables (Figure 3) : la souche PAV constitue 52 % des isolats transmis par les pucerons piégés de septembre à novembre, et 56 % de ceux détectés au champ d'octobre à décembre. La correspondance est moins bonne pour les deux autres souches : la part de RPV est moins importante dans les isolats détectés au champ (12 %) qu'elle ne l'est dans ceux transmis par les pucerons piégés (24 %). C'est l'inverse pour la souche MAV.

DISCUSSION & CONCLUSION

Les quantités de pucerons capturées chaque semaine par le piège à succion de 1,5 m représentent entre 10 et 25 % des captures correspondantes au piège de 12,2 m, ce qui est en accord avec les résultats de PLUMB (1976) et plus récemment de SIMON (1991). L'allure générale des courbes de vol est la même dans les deux cas ce qui indique qu'il ne semble pas y avoir de biais entre les deux types d'échantillonnages pour les captures de *R. padi*, tous morphes confondus. Le rapport entre les quantités de pucerons capturées par les deux pièges explique également pourquoi aucun *S. avenae* ou *M. dirhodum* n'a été piégé à 1,5 m. Plus généralement cette dominance de *R. padi* sur les autres espèces inféodées aux graminées n'est pas étonnante ; cette espèce, abondamment multipliée de septembre à novembre par le maïs et les graminées fourragères, constitue plus de 90 % des captures de pucerons des céréales au cours de la même période au piège de 12,2 m du Rheu, de 1983 à 1987 (GILLET *et al.*, 1990).

Le pourcentage de pucerons virulifères capturés au piège de 1,5 m est globalement élevé (35 %) sur toute la période de capture, mais particulièrement en septembre. Ceci est beaucoup plus fort que ce qui est enregistré en Grande Bretagne, où sur 13 années les pucerons virulifères n'ont jamais dépassé 11,5 % du total mensuel piégé (PLUMB *et al.*, 1986) dans le cas de la J.N.O. Par contre, nos résultats sont cohérents avec l'estimation par l'intermédiaire de plantes pièges disposés sur le terrain, du pouvoir virulifère moyen (de 29 à 56 % selon les semaines) des *R. padi* à l'automne 1989 (LADEVEZE, com. pers.) au Rheu. Ceci

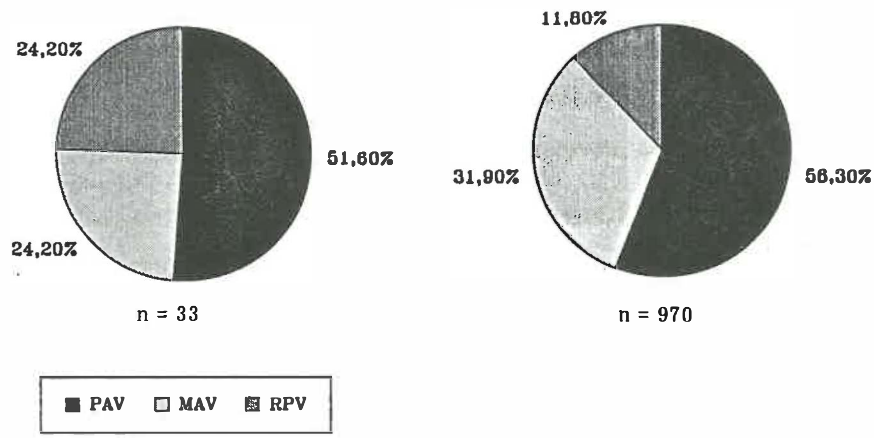


Figure 3 : Pourcentages relatifs des isolats viraux transmis par les pucerons piégés (A) et détectés dans la parcelle d'orge (B) en automne 1989 (n : nombre d'échantillons).

confirme la gravité des risques potentiels dus à la J.N.O. dans cette région. Le fait que nous n'ayons pas trouvé de pucerons virulifères en novembre peut tenir à la taille de l'échantillon récolté (9). Cependant PLUMB (1976) n'en signale pas non plus dans le Sud de l'Angleterre, ce qui est également le cas certaines années au pays de Galles (A'BROOK & DEWAR, 1980). Ceci peut être dû à une action des basses températures sur l'acquisition des virus par les pucerons, mais également au fait que les plantes d'origine des pucerons capturés à cette époque n'étaient pas ou peu contaminées.

Parmi les isolats transmis par les pucerons capturés, PAV est prédominant, ce qui parait refléter la situation globale dans les réservoirs automnaux de *R. padi* : Maïs (HENRY & DEDRYVER, 1989 ; END, com. pers.) et graminées fourragères (HENRY & DEDRYVER, 1991). Cependant l'importance de RPV, qu'on ne détecte pas dans le maïs (HENRY & DEDRYVER, 1989 ; END, com. pers.) dans nos échantillons, peut tenir aux conditions particulières de l'été 1989. Le maïs ayant été récolté début septembre 1989 dans la région d'étude du fait de la sécheresse, la principale source de pucerons à l'automne devait être cette année-là les graminées fourragères, essentiellement les ray-grass, uniquement contaminés par PAV et RPV (HENRY & DEDRYVER, 1991).

Nous mettons d'autre part en évidence la possibilité pour *R. padi* de transmettre en conditions naturelles la souche MAV en mélange avec d'autres souches, probablement par transencapsidation, tel que cela a été montré au laboratoire par ROCHOW (1977).

Enfin la bonne relation observée entre les fréquences respectives des différentes souches au champ et transmises par les pucerons capturés, confirme l'intérêt de ce type d'expérimentation pour l'amélioration des méthodes de prévision des risques dus à la J.N.O.

BIBLIOGRAPHIE

A'BROOK J., DEWAR A.M., 1980. Barley yellow dwarf infectivity of alate aphid vectors in west Wales. *Ann. appl. Biol.* 96, 51-58.

GILLET H., DEDRYVER C.A., ROBERT Y., GAMON Agnès, PIERRE J.S., 1990. Assessing the risk of primary infection of cereals by barley yellow dwarf virus in autumn in the Rennes basin of France. *Ann. appl. Biol.* 117, 237-251.

HENRY Monique, DEDRYVER C.A., 1989. Fluctuations in cereal aphid populations on maize (*Zea mays*) in western France in relation to the epidemiology of barley yellow dwarf virus (BYDV). *J. Appl. Ent.* 107, 401-410.

HENRY Monique, DEDRYVER C.A., 1991. Occurence of barley yellow dwarf virus in pastures of western France. *Plant pathology* 40, sous presse.

HULLE M., GAMON Agnès, 1989. Relations entre les captures de pièges à succion du réseau AGRAPHID. In "Euraphid netwok : trapping and aphid prognosis". Proceedings of an EC Experts' meeting Catane 7-9 novembre 1988, *Cavalloro Ed.* p. 153-164.

LECLERCQ-LE QUILLEC Françoise, DEDRYVER C.A., 1990. Dissémination des virus de la J.N.O. en parcelles d'orge d'hiver, en relation avec l'évolution des populations de pucerons vecteurs. Effet d'un aphicide appliqué en traitement de semences. ANPP, 2è Conférence Internationale sur les ravageurs en agriculture, Versailles, 4-6 décembre 1990. p. 757-764.

PIERRE J.S., DEDRYVER C.A., BAYON F., FOUGEROUX A., GAMON Agnès, GILLET H., de la MESSELIERE C., TAUPIN P., 1987. Prévisions statistiques des pullulations de *Sitobion avenae* et de la vection du virus de la jaunisse nanisante de l'orge par *Rhopalosiphum padi*. *C.R. Acad. Agric. Fr.*, 73 (7), 153-167.

PLUMB R.T., 1976. Barley yellow dwarf virus in aphids caught in succion traps, 1969-73. *Ann. appl. Biol.* 83, 53-59.

PLUMB R.T., LENNON E.A., GUTTERIDGE R.A., 1986. Forecasting barley yellow dwarf virus by monitoring vector populations and infectivity. In : "Plant virus epidemics monitoring, modelling and predicting outbreaks". Eds : McLEAN G.D., GARRET R.G. & RUESINK W.G., Academic Press, Sydney p. 387-398.

ROBERT Y., CHOPIN DE JANVRY E., 1977. Sur l'intérêt d'implanter en France un réseau de piégeage pour améliorer la lutte contre les pucerons. *Bull. Techn. Inform. Min. Agr.*, 323, 559-568.

ROCHOW W.F., 1970. Barley yellow dwarf virus. CMI/AAB *Description of plant viruses*, 32, 4 p.

ROCHOW W.F., 1977. Dependant transmission from mixed infections. In "Aphids as virus vectors". HARRIS K. & MARAMOROSCH K. Eds. *Academic Press* N.Y. p. 253-273.

SIMON J.C., 1991. Etude de la variabilité du cycle évolutif et recherche de son déterminisme chez le puceron des céréales *Rhopalosiphum padi* L. (Homoptera : Aphididae). Thèse Doc. Université Paris 6. 94 pp.

TORRANCE L., 1987. Use of enzyme amplification in an ELISA to increase sensitivity of detection of Barley yellow dwarf virus in oats and in individual vectors aphids. *J. Virol. Meth.* 15, 131-138.

ADVANCES IN THE KNOWLEDGE OF BYDV EPIDEMIOLOGY IN SPAIN

J. COMAS, X. PONS & R. ALBAJES

Centre d'Investigació i Desenvolupament Agrari de Lleida
Area de Protecció de Conreus
Av. Alcalde Rovira Roure, 177. 25006 Lleida

SUMMARY

Ocurrence of BYDV in the main regions growing cereal in Spain is exposed. In Northeast Spain the infectivity of winged aphid vectors colonizing winter cereal and maize has been investigated. A significant rate of alates tested were infective. Up to now testing results against PAV, RPV and MAV monoclonal antibodies seem to show that PAV is the prodominant isolate.

1.- Update results on cereal aphid dynamics in Northeast of Spain.

Since 1983 we have been working on cereal aphid dynamics in the Northeast of Spain. The main features pointed out on the preceding meetings of IOBC (Pons & Albajes 1987a, 1987b; Comas *et al.* 1989) are the following:

- Aphid population is maintained troughout the season on winter cereal, maize and forage cereal as a result of aphid host crops overlapping. In our area due to the fact that most crops are under irrigation, forage cereal is sown quite early (September) and consequently there is aslo a good overlapping between maize and forage cereal.

- *Rhopalosiphum padi*, *Sitobion avenae*, and *Metopolophium dirhodum* are the most important species.

- Winter cereal crops emerging before the beginning of mid December are colonized by aphids in autumn. At that moment *R.padi* is the most frequent species.

- Cereal aphids have an anholocyclic behaviour in our area. Aphids overwinter on cereals (aphid survival depends on the hardiness of the winter).

- In spring the predominant species on winter cereal is *S.avenae*. *S.avenae* is also the most important species arriving at maize.

- In our area cereal aphids mainly oversummer on maize. At the beginning of autumn the predominant species on maize is *R.padi*. Population levels of *S.avenae* are much lower.

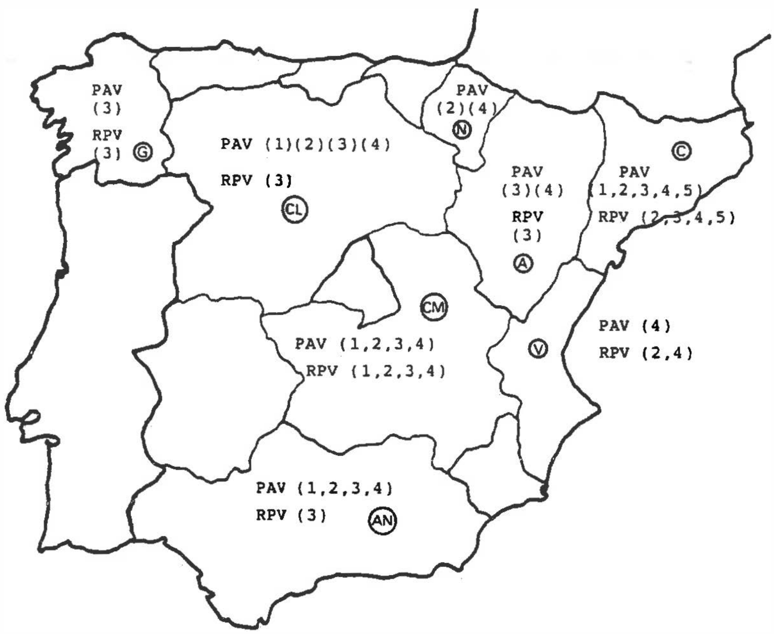


Figure 1.- BYDV strains identificated by different authors in the main spanish regions where cereal is cultivated.

REGIONS	
CM	: Castilla-La Mancha
CL	: Castilla-Leon
AN	: Andalucia
A	: Aragon
C	: Catalonia
G	: Galicia
N	: Navarra
V	: Valencia

SOURCE	
(1):	Lister et al, 1990
(2):	Jordá et al., 1990
(3):	Moriones et al.,1990
(4):	Osca, 1990
(5):	Own data

- At that moment colonization by aphids on forage cereal (usually associated with vetch) is important.

2.- BYDV research in Spain.

Table 1 shows in the main Spanish regions where winter cereal is cultivated, the surfaces devoted to crops which can act as cereal aphid hosts. In Table 2 the percentages of each host related to total cereal aphid hosts surface is indicated.

Table 1.- Surfaces (x10^3 ha) devoted to crops that can act as cereal aphid hosts in the main regions of Spain where winter cereal is cultivated.

Region	winter cereal	forage cereal	maize	forage maize	rice
Castilla-La Mancha	2335	29.0	5.5	6.0	0
Castilla-Leon	1383	41.5	30.0	3.5	0
Andalucia	998	67.0	56.0	9.0	26
Aragon	854	11.5	4.5	4.0	2
Catalonia	315	26.0	34.5	11.5	18
Galicia	89	42.5	147.0	44.0	0
Navarra	188	4.3	16.0	0.5	0
Valencia	27	1.5	6.0	0.5	16
SPAIN	6931	431.0	418.0	104.0	68

Table 2.- Percentage of cereal aphid hosts related to total surface devoted to crop that can act as cereal aphid hosts.

	winter cereal	forage cereal	maize	forage maize	rice
Castilla-La Mancha	98.2	1.3	0.3	0.2	0.0
Castilla-Leon	94.8	3.0	2.0	0.2	0.0
Andalucia	87.0	5.0	5.0	0.4	0.2
Aragon	93.2	1.2	5.0	0.4	0.2
Catalonia	77.5	6.5	8.5	3.0	4.5
Galicia	27.5	13.0	45.6	13.8	0.0
Navarra	90.1	2.0	7.7	0.2	0.0
Valencia	53.0	3.0	11.7	1.0	31.3

Figure 1 indicates the BYDV strains identificated in Spain by diferent authors.

3.- BYDV presence in Northeast Spain.

Since autumn 1987 we have been looking for the presence of BYDV in our area. At the beginning we tested samples against Bioreba B polyclonal, and later against PAV, RPV and MAV monoclonal antibodies supplied by the Harpenden Laboratory, MAFF (UK).

- Presence of BYDV on aphid hosts.

Winter cereal fields.

In the spring of 1988 the percentage of cereal fields infected was very high (85%), while in the spring of the following year was much lower (10%).

	fields tested	% infected
spring 1988	50	85
spring 1989	35	10

Forage cereal fields.

Results from the winters of 1988 and 1989 show that the percentage of infected fields is always very high. In cereal volunteers the presence of BYDV inocculum is also very important.

	Fields tested	% infec.	Cereal vol. tested	% infec.
winter 1988	15	94	10	100
winter 1989	14	90	12	80

Maize.

Samples from maize fields are still to be processed. Apterous nymphs caught in maize fields at the end of the season turned to be infective.

- Infectivity of cereal alate aphids.

Alates colonizing winter cereal crops.

In the autumn of 1987 15% of alates arriving at the crop were infective. In autumn 1988, 31% of alates were infective.

	alates caught		% infective	
	Sa	Rp	Sa	Rp
autumn 1987	8	25	0	20
autumn 1988	18	137	0	32

Alates colonizing maize.

In the spring of 1988, 28% of alates arriving at maize were infective.

	alates caught		% infective	
	Sa	Rp	Sa	Rp
spring 1988	43	98	4	38

- The latest samples, tested against Harpenden Laboratory monoclonal antibodies, seem to show that PAV is the predominant isolate.

4.- Discussion and future research.

1) In our area BYDV is maintained on the different cereal aphid hosts all over the year. Alate aphids colonizing winter cereal and maize have shown to be infective in a significant rate. Consequently factors affecting aphid population dynamics through the different crops should to be considerably important in the widespreading of the disease.

Forage cereals seem to have special importance as an aphid host since this crop has always been found to be infected in a high rate not depending on the year considerated. Although the surface devoted to forage cereal (usually associated with vetch) is not very large it is widely distributed all over the region.

2) Most of the infective alate aphids colonizing winter cereal in autumn are *R.padi*. This fact and the consideration that *R.padi* is always the predominant species arriving at winter cereal points to the prevailing role of *R.padi* as the main cause for BYDV inocculum spreading over winter cereal.

3) *R.padi* survival on winter cereal depends on the hardiness of the winter. Mild winters allow R.padi populations to be maintained through the winter on winter cereal and in spring the increase of population could be very high and therefore the transmission of BYDV to maize.

4) In severe winters *S.avenae* survives better on winter cereal than *R.padi*. So in hard winters *S.avenae* is the main BYDV vector

from winter cereal to maize. The virus will be spread by *R.padi* from maize to winter cereal later on in the season.

5) Since PAV is transmited by both *R.padi* and *S.avenae*, the transmission of this strain is assured through the different hosts along the year in our area. According to Foxe and Rochow (1975), *R.padi* is more efficient in the transmission of PAV than *S.avenae*. This fact remarks the role of *R.padi* in PAV epidemiology.

In spring the transmission of BYDV from winter cereal to maize is mainly due to *S.avenae*, specially in hard winters, so the transmission of RPV is partially broken.

In autumn the transmission of BYDV from maize to winter cereal is caused mainly by *R.padi*, so the transmission of MAV is also partly broken.

This reasoning lets us explain why PAV could be the most important strain in Spain and also in our area. This agrees with the preliminar results obtained using Harpenden Laboratory monoclonals. Although further studies should to be done to confirm this preliminar hypothesis.

6) In the next future studies should be done to assess the importance of long distance aphid migrations. Such studies could partially modifie this pattern.

REFERENCES

ANONYMOUS. 1987. Anuario de Estadística Agraria. Ministerio de Agricultura Pesca y Alimentación. Madrid.

COMAS,J.; PONS,X.; ALBAJES,R. 1989. A five year study of cereal aphid biology in Catalonia. WPRS Bull. 12(1), 12-16.

FOXE, M.J.; ROCHOW, W.F. 1975. Importance of virus source leaves in vector specificity of barley yellow dwarf virus. *Phytopathology*, 65, 1124-1129.

JORDA,C.; OSCA,J.M.; ALFARO,A. 1990. Barley yellow dwarf in Spain. In Burnett, P.A., ed. 1990. Wolrd perspectives on barley yellow dwarf. CIMMYT, Mexico, D.F., Mexico. pp: 45-48.

LISTER,R.M; FERERES,A.; FOSTER,J.E.; CASTAÑERA,P. 1990. Occurence of barley yellow dwarf virus in three major cereal-growing regions of Spain. Wolrd perspectives on barley yellow dwarf. CIMMYT, Mexico, D.F., Mexico. pp: 45-48.

MORIONES,E.; ORTEGO,F.; RUIZ-TAPIADOR,M.; GUTIERREZ,C.; CASTAÑERA,P.; GARCIA-ARENAL,F. 1989. Epidemiología del virus del enanismo amarillo de la cebada en España. Proc. VII Congreso Nacional de Fitopatología. Badajoz, 17-20 October 1989.

OSCA,J.M. 1990. Características de las razas españolas del virus del amarilleo enanizante de la cebada (BYDV). Tesis Doctoral. Universidad Politécnica de Valencia. Escuela Técnica Superior de Ingenieros Agrónomos. 294 pp.

PONS,X.; ALBAJES,R. 1987a. Biology of BYDV vectors in wheat in Catalonia (Spain). WPRS Bull., 10(1): 36-41.

PONS,X.; ALBAJES,R. 1987b. Role of corn and the vetch+cereal associated crop in BYDV vector populations in Catalonia (Spain). WPRS Bull., 10(1): 42-45.

AKNOWLEDGEMENTS

Thanks are due to the CICYT, which partially funded this work (Project 1174/84).

SPRING ACTIVITY ASSESSMENT OF PARASITOIDS IN WESTERN FRANCE BY EXPERIMENTAL EXPOSURE OF CEREAL APHIDS ON TRAP PLANTS IN A WHEAT FIELD.

C.A. DEDRYVER(1), VERONIQUE CREACH(2), J.M. RABASSE(3) and J.P. NENON(2)

(1) INRA, Laboratoire de la Chaire de Zoologie de l'ENSAR, Domaine de la Motte, F35650 LE RHEU.

(2) Laboratoire d'Entomologie fondamentale et appliquée, Université de Rennes I, Campus de Beaulieu, F35042 RENNES Cedex.

(3) INRA, Laboratoire de Biologie des Invertébrés, 37 boulevard du Cap, F06602 ANTIBES.

RESUME

L'exposition dans un champ de blé de plantes pièges infestées par des quantités égales de *Rhopalosiphum padi* L., *Sitobion avenae* F., et *Metopolophium dirhodum* Wlk. a permis d'estimer l'activité de leurs parasitoïdes au printemps. Celle-ci est la plus importante de mars à début mai, lorsque les populations de pucerons sont faibles ; le pourcentage de pucerons parasités décroît ensuite de mai-juin à juillet. La principale espèce d'Aphidiide est *Aphidius uzbekistanicus* Luz., dont la préférence parasitaire et la sex-ratio paraissent instables au cours du temps.

Cereal aphids are commonly parasitized in the fields by Hymenoptera, mainly Aphidiids (LATTEUR, 1973 ; DEAN, 1974 ; STARY, 1976 ; RABASSE & DEDRYVER, 1983), but the real effect of these parasitoids on the population dynamics of their hosts is still unclear in spite of some recent attempts to simulation modelling (VORLEY & WRATTEN, 1985).

Although several methods are available for estimating levels of parasitization in the field, like aphid dissection (ROBERT, 1979 ; DEDRYVER & GELLE, 1982 ; DEDRYVER, 1987), aphid rearing (DEAN, 1974) or electrophoresis (HÖLLER & BRAUME, 1988 ; WALTON *et al.*, 1990), the changes with time of aphid species composition, aphid density and repartition in the field and on the plant, make intraseasonal and between years comparisons rather difficult.

As an example, some of the results (DEDRYVER, 1987 ; WALTON *et al.*, 1990) pointed out that in oceanic areas like Western France and Southern England, cereal aphids parasitization can be very high at the beginning of spring. This was correlated or not with subsequent low aphid populations levels. At this period, aphids are rare in the field and more accurate methods are requested because the samples are small and not reliable.

This paper reports an attempt to quantify spring activity of cereal aphids parasites in the oceanic conditions of the Rennes basin (West of France), in 1988. A method for exposing trap plant in a wheat field, similar to that developped by CAMERON *et al.* (1984) was used to avoid direct dependence on the field density of aphids. Parasitization of a constant sample of different aphid species was assessed from March to July. In addition, it was possible to study more accurately some components of parasite biology like host preference and sex-ratio.

MATERIALS AND METHODS

. <u>Assessment of the primary parasites activity</u>

A standard exposure unit (S.E.U.) consisted in a pot, 10 cm in diameter, containing 25 wheat seedlings (cv. Arminda) infested by an equal number of aphids of the 3 species *Rhopalosiphum padi* L., *Sitobion avenae* F. and *Metopolophium dirhodum* Wlk. Aphids were obtained from laboratory cultures reared at 20°C, L16 : D8. The experiments were done in a winter wheat field (cv. Arminda) near LE RHEU (INRA Exp. Stn. of Rennes) at 6 to 9 exposure locations 10 x 10 m distant from each others.

A first succession of experiments (23/3, 30/3, 8/4, 13/4, 21/4, 28/4, 4/5) consisted in a 24 h exposition of one S.E.U. in each of the nine locations at the canopy level, with 30 second instar larvae of each aphid species per S.E.U..

During a second succession of experiments, two different S.E.U. were exposed at the canopy level during 24-36 h on each of 6 locations : one consisted in 20 second instar larvae of each species per wheat pot, the second in 20 fourth

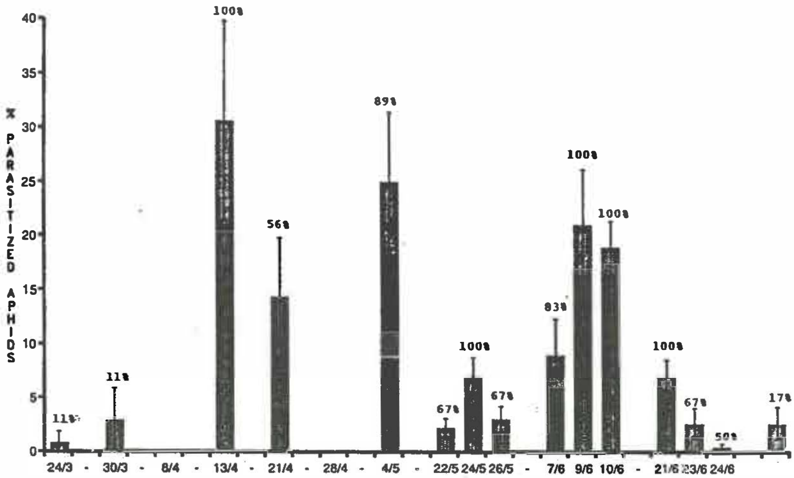


Figure 1 : Percentages of parasitized aphids in the S.E.U. (■) with standard Deviation, and percentage of S.E.U. with parasitized aphids (%) for each date of experiment.

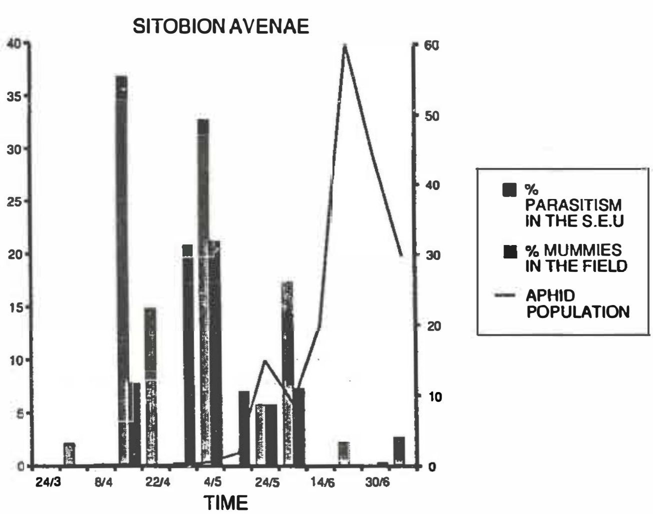


Figure 2 : Mean numbers of *S. avenae* per sample of 20 tillers in the wheat field (–) with associated percentages of mummies at field (■) and percentages of *S. avenae* parasitized in the S.E.U. (▤).

instar larvae of each species. Twelve experiments were done, grouped by series of 3-4 consecutive days (23, 24, 25/5 ; 8, 9, 10/6 ; 21, 23, 24/6 ; 7, 9, 10/7). For each experiment the results concerning the 2 S.E.U. were finally pooled together, no significant difference being found between parasitization of young and old larvae.

After the field exposition, S.E.U. were brought back to the laboratory for aphid loss assessment ; then the pots were covered with a cellophane bag and placed outdoors, under shelter. Mummification was daily checked and mummies were individually tubed and kept outdoors. Emergences were observed daily. The shelter temperature was registered during the whole experiment. Finally adult parasitoids and their aphid hosts were identified in the laboratory.

. Sampling the field populations of cereal aphids

Living cereal aphids and mummies were sampled and visually identified weekly in the wheat field from March 23rd to the end of July on 50 to 10 batches (depending on aphid density) of 20 consecutive tillers. The batches were 10 x 10 meters distant from each other in the field.

. Statistical analysis were achieved using the package STAT-ITCF version 5 (TRANCHEFORT *et al.*, 1987).

RESULTS

* Assessment of parasitism and comparison with aphid populations in the field.

For the whole period of experiment 922 mummies were collected in the S.E.U., 85.7 % of the emerged adult primary parasitoids were *A. uzbekistanicus*. The other species were *Aphidius matricariae* HAL. (6.4 % of the emerged adults), *Aphidius picipes* NEES (2 % of the emerged adults) and *Praon* sp. (0.5 %). One specimen of *Aphidius ervi* HAL. emerged. The parasites died in 5.4 % of the mummies.

Percentages of parasitism were calculated for each date, taking into account the loss of aphids during the exposition time. Figure 1 shows large variations between days and between weeks of experiment. In March and April there were no parasitism at all on April 8th and less than 1 % on April 28th, but up to 31 % on April 13th which is the higher mean level of parasitism recorded during all the experimental period. In May and June there is evidence of large between days variations. More generally, the level of parasitism appears cahotic at the beginning of spring, then increase between the end of May and beginning of June and finally decrease in June to become very low at the end of June and

D.F. = 12	T MIN.	T MAX.	T MEAN.	INSOL.	RAD.	RAIN.	HUME.
Day preceding the exposition of the S.E.U.	- 0.26	0.03	-0.096	0.600 *	0.550 *	-0.534 *	-0.184
Day of the exposition of the S.E.U.	-0.161	0.138	0.007	0.540 *	0.550 *	-0.098	-0.041

Table 1 : Coefficient of correlation between the percentage of parasitized aphids in the S.E.U. and some climatic data : T MIN. : minimal daily temperature (°C) ; T MAX. : maximal daily temperature (°C) ; T MEAN : mean daily temperature (°C) ; INSOL : daily insolation (in hours) ; RAD. ; daily radiance (in mega J/m^2) ; RAIN : daily rainfall (in mm.) ; HUME : daily humectation (in hours) (* significant : $\alpha < 0.05$)

	S. avenae	*M. dirhodum*	*R. padi*	2
A. uzbekistanicus	384	227	278	20.47 ***
A. picipes	13	5	0	8.27 **
A. matricariae	22	2	33	25.99 ***

Table 2 : Number of *A. uzbekistanicus*, *A. picipes* and *A. matricariae* emerged from the different aphid species from the S.E.U. and relevant χ^2 homogeneity tests. (** $P < 0.01$; *** $P < 0.001$).

beginning of July. Three main peaks of activity for parasitoïds appear on Figure 1 : mid-April, beginning of May and beginning of June.

Figure 2 represents for *S. avenae*, the total field population with percentage of mummified aphids in the field, and percentage of parasitism in the S.E.U.. The periods of maximal efficiency of parasitoids as measured by both methods correspond to some extend. The parasitoids appeared very efficient between April and beginning of May when aphid populations is very low. At the peak of the aphid population, levels of parasitism were lower than 5 % in the S.E.U..

The relationship between daily percentages of parasitism in the S.E.U. and climatic factors is shown on table 1. The only significant correlations were found with insolation and radiance of the exposition day of the S.E.U. and for the preceding days (in positive) and for the rainfall of the preceding day (in negative).

* Parasitism of the different aphid species

Total numbers of adults of the 3 main parasitoid species emerged from each aphid species are shown on table 2. *S. avenae* was more parasitized by *A. uzbekistanicus* than *R. padi* and *M. dirhodum*. *A. picipes* emerged mainly from *S. avenae* and no *R. padi* parasitized by this species was found. *A. matricariae* emerged more from *R. padi* than from *S. avenae*. A very low number of *M. dirhodum* was parasitized by this species.

Moreover figure 3 shows a change with time of the preferences of the more abundant parasitoid, *A. uzbekistanicus*. At the beginning of the spring, *R. padi* was more parasitized than the other species (all mummies collected on March 23^{rd} were *R. padi*). From mid April to the beginning of May, 50 % of the parasitized aphids were *S. avenae* and from the end of May to the beginning of June the 3 species were equally parasitized. At the end of June *S. avenae* was clearly less parasitized than both other species. Figure 4 shows a linear relationship and a significant correlation between the percentage of each aphid species in the field and its percentage in the relevant mummy sample from S.E.U.. Larger was the relative importance of one species in the field, more this species seemed prefered in the S.E.U..

* Sex-ratio of the parasites

The sex-ratio of *A. uzbekistanicus* was calculated for the 4 larger samples from the S.E.U.. It reached approximately 1/1 for the 3 first dates of sampling and 60 females/40 males on June 10^{th}. The sex-ratio differed with the aphid host (figure 5) being more stable and higher for parasitoids emerging from

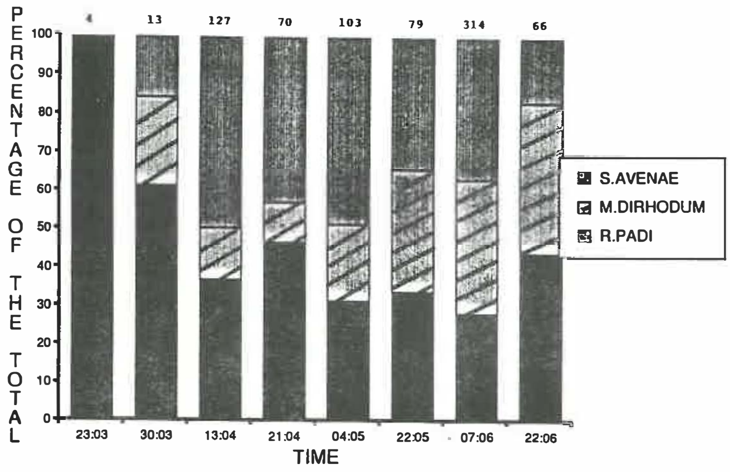


Figure 3 : Percentages of the 3 aphid species in the *A. uzbekistanicus* mummies sample at each date of experiment, with the size of the sample (numbers).

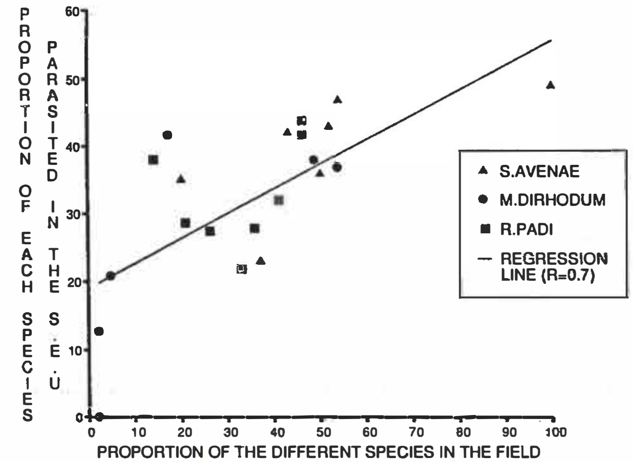


Figure 4 : Relationship between the population of each aphid species in the field and the corresponding proportion of each aphid species in the mummy sample of the S.E.U.

S. avenae (50-60 % females) than from *R. padi* (40-52 % females). The sex-ratio of parasitoids emerging from *M. dirhodum* appeared very unconstant and increases with time (41 % females on April 14th to 72.5 % on June 10th).

DISCUSSION

* On the method

The trap-plant method used in this study, and before by CAMERON *et al.*, (1984), was an attempt to standardize comparisons to a certain extent. It allows to compare 24 hours parasites activity, in *a posteriori* precisely-known climatic conditions. It allows also to get a more standard index for parasitoid activity, as variations in numbers, age structure and plant repartition of the aphid populations do not appear any longer. For the same reasons, its value is relative and does not express the pure reality in the field, but a potential parasitoid activity at a given time.

* On the results

Concerning the potential activity of parasitoïds in the field, two main points are obvious from our results : i) a very early and irregular activity of the parasites when aphid populations are inexistant or very low ; ii) a general decrease of the parasitism levels from the beginning of June to July, as aphid populations increase.

Previous results from dissection (DEDRYVER, 1987), rearing (DEAN, 1974 ; VORLEY & WRATTEN, 1985) or electrophoresis (WALTON *et al.*, 1990) of living aphids collected in the field, pointed out that, in oceanic areas, parasitism level could be very high in early spring. Our experiments confirm the possibility for parasitism to reach very high levels (up to 35 %) in April or May in the Rennes basin. This seems to be due to temporary high activity of the parasites, probably partly dependant of some climatic factors not systematically correlated with temperature like insolation and radiance, the importance of which was until now neglected in Aphidiid behaviour studies. The role of these factors on the take-off, of insects specially aphids, is well-known (ROBERT, 1987) and STARY (1970) indicated that insolation and temperature were of major importance for Aphidiid activity.

The existence at a local scale of a parasite stock when hosts are very rare in the field, could be related with the way for the parasites and aphids to overwinter in oceanic areas. Cereal aphids overwinter mainly parthenogenetically on various Gramineae in the these regions (DEDRYVER &

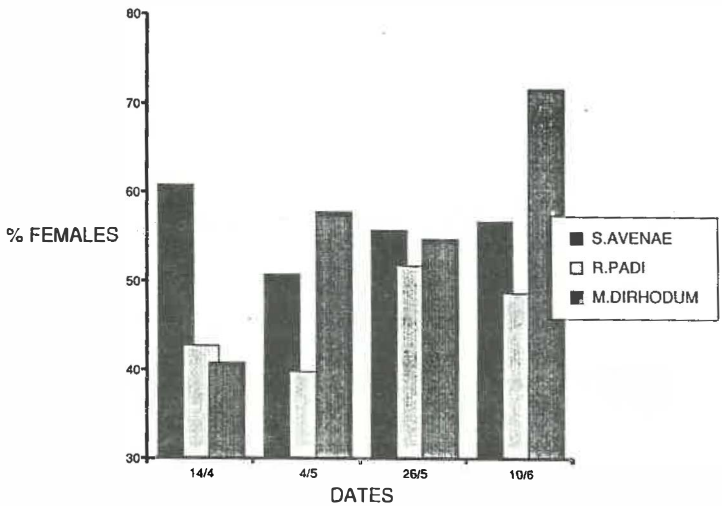


Figure 5 : Sex ratio (% of females) of the *A. uzbekistanicus* sample for the 3 species of aphids

GELLE, 1982) and their parasites develop continuously in their hosts during winter without diapause (KRESPI, 1990). Therefore, the reservoirs of overwintering aphids (volunteers, grasses) produce in early spring large quantities of parasites able to spread to adjacent crops when climate is temporary favourable. The role of these parasites could be limited in the fields by the low aphid populations and their dispersion, involving a high effort for host-searching in the short time when climate is suitable.

The progressive decrease from June to July of parasitism level was still recorded by classic field sampling (DEDRYVER, 1987 ; WALTON *et al.*, 1990). One of the reasons can be a problem of Aphidiid disponibility caused both by hyperparasitism and by field abundance of aphids.

This work corroborates numerous results of field observations showing that *A. uzbekistanicus* is the dominant cereal aphids parasitoid as in many european countries (LATTEUR, 1979 ; CASTANERA, 1982 ; POWELL, 1982 ; RABASSE & DEDRYVER, 1983 ; DEDRYVER, 1987). More original are the results concerning *A. matricariae* a polyphagous species which was known to be important on *R. padi* in oceanic countries in early spring (RABASSE & DEDRYVER, 1982). It appears from our experiment that this species does not parasite *M. dirhodum* or very few but has no clear preference between *R. padi* and *S. avenae*, which confirms some field results from KRESPI (1990).

The exposure of equal quantities of the 3 species of cereal aphids to natural parasitism allowed us to get a contribution to the field study of host preference. Our results agree partly with those of IBRAHIM (1987) who showed in the laboratory that *S. avenae* was preferred by *A. uzbekistanicus*, which is generally the case in our experiments. IBRAHIM (1987) indicated too, that, after *S. avenae*, the next prefered species for *A. uzbekistanicus* was its previous host. This can explain partly the change of host preference with time that we recorded, and the obvious relationship between the preference for a species and its field abundance. Particularly the preference in early spring for *R. padi* could be due to the high proportion of this species in the overwintering parthenogenetic aphid populations in various reservoirs.

Finally the increase with time of the sex-ratio of *A. uzbekistanicus* was still observed by HÖLLER (1984) who suggested some relationships with temperature. FLANDERS (1965) observed that for some species of hymenoptere, mated eggs were laid in the most suitable hosts, which could be related with our results concerning the higher and more stable sex-ratio of *A. uzbekistanicus* emerging from *S. avenae*.

In conclusion, the role of parasitism in aphid population dynamics is a complex phenomenon that can not be explained only by field observations and laboratory trials which give very different kinds of results. The linkage between them can be done by experimental field trials in which some components of the plant-host-parasitoid system are fixed.

REFERENCES

CAMERON P.J., POWELL W., LOXDALE H.D., 1984. Reservoirs for *Aphidius ervi* Haliday (Hymenoptera : Aphidiidae), a polyphagous parasitoid of cereal aphids (Hemiptera : Aphididae). *Bull. Ent. Res.*74, 647-656.

CASTANERA P., 1983. The relative abundance of parasites and predators of cereal aphids in central Spain. In : *Aphid Antagonists*. R. Cavalloro Ed. 76-82.

DEAN G.J., 1974. Effects of parasites and predators on the cereal aphids *Metopolophium dirhodum* (Wlk.) and *Macrosiphum avenae* (F.) (Hem., Aphididae). *Bull. Ent. Res.* 63, 411-422.

DEDRYVER C.A., 1987. Biologie, écologie et dynamique de population des pucerons des céréales en climat océanique. Thèse Doc. Sciences, Université Paris Sud (Orsay), 199 pp.

DEDRYVER C.A., GELLE A., 1982. Biologie des pucerons des céréales dans l'Ouest de la France. IV. - Etude de l'hivernation de populations anholocycliques de *Rhopalosiphum padi* L., *Metopolophium dirhodum* Wlk. et *Sitobion avenae* F. sur repousses de céréales dans trois stations de Bretagne et du Bassin parisien. *Acta Oecologica, Oecol. Applic.* 3, 321-342.

FLANDERS S.E., 1965. On the sexuality and sex-ratios of hymenopterous parasites. *Amer. Naturalist*, 99, 489-494.

HÖLLER C., 1984. Untersuchungen zur Biologie der Parasitoiden (*Hymenoptera, Aphidiidae*) der Getreideblattlause. Diplomarbeit aus der Institut für Phytopathologie, Kiel, 106 pp.

HÖLLER C., BRAUME H.J., 1988. The use of isolectric focusing to assess percentage hymenopterous parasitism in aphid populations. *Entomol. exp. appl.* 47, 105-114.

IBRAHIM A.M.A., 1986. Studies on *Aphidius uzbekistanicus* LUZ., (*Hymenoptera : Aphidiidae*) parasitoid of the cereal aphids *Sitobion avenae* F., *Metopolophium dirhodum* Wlk. and *Rhopalosiphum padi* L. Thesis Doc. Cairo University, 194 pp.

KRESPI L., 1990. Etude de la biocenose parasitaire des pucerons des céréales dans le Bassin de Rennes : cas particulier d'*Aphidius uzbekistanicus* LUZ. Thèse Doctorat Université Rennes I., 105 pp.

LATTEUR G., 1973. Etude de la dynamique de population de pucerons des céréales. Premières données relatives aux organismes aphidiphages en trois localités différentes. *Parasitica* 29, 134-151.

POWELL W., 1983. The role of parasitoids in limiting cereal aphid populations. In Aphid antagonists. R. Cavalloro Ed. 50-56.

RABASSE J.M., DEDRYVER C.A., 1982. Overwintering of primary parasites and hyperparasites of cereal aphids in Western France. In Aphid antagonists. R. Cavalloro Ed. 57-64.

RABASSE J.M., DEDRYVER C.A., 1983. Biologie des pucerons des céréales dans l'ouest de la France. III - Action des hymenoptères parasites sur les populations de *Sitobion avenae* F., *Metopolophium dirhodum* Wlk. et *Rhopalosiphum padi* L. Agronomie, 3, 779-790.

ROBERT Y., 1979. Recherches écologiques sur les pucerons *Aulacorthum solani* Kltb., *Macrosiphum euphorbiae* Thomas et *Myzus persicae* Sulz. dans l'Ouest de la France. III - Importance du parasitisme par hymenopteres *Aphidiidae* et par *Entomophthora* sur pommes de terre. *Ann. Zool. Ecol. anim.*, 11, 371-388.

ROBERT Y., 1987. Dispersion and migration. In : Aphids, their biology, natural ennemies and control (Vol 2A). A.K. Minks & P. Harrewijn (Eds), Elsevier, Amsterdam, 299-313.

STARY P., 1970. Biology of aphid parasites. Series Entomologica, Junk, den Haag, 643 pp.

STARY P., 1976. Parasite spectrum and relative abundance of parasites of cereal aphids in Czechoslovakia (Hymenoptera : Aphidiidae ; Homoptera : Aphidoidea). *Acta entomol. bohemoslov*, 73, 216-223.

TRANCHEFORT J., BEAUX M.F., GOUET J.P., PHILIPPEAU G., VERNEAU M., 1987. STAT-ITCF. Manuel d'utilisation. I.T.C.F., PARIS. 208 pp.

VORLEY W.T., WRATTEN S.D., 1985. A simulation model of the role of parasitoids in the population development of *Sitobion avenae* F. (Hemiptera : *Aphididae*) on cereals. *J. appl. Ecol.*, 22, 813-823.

WALTON M.P., POWELL W., LOXDALE H.D., ALLEN-WILLIAMS L., 1990. Electrophoresis as a tool for estimating levels of hymenopterous parasitism in field populations of the cereal aphid, *Sitobion avenae*. *Entomol. exp. appl.*, 54, 217-279.

Some aspects of host selection by two aphid hyperparasitoids: *Asaphes vulgaris* Wlk. and *Asaphes suspensus* (Nees) (Hymenoptera: Pteromalidae)

Petra Christiansen - Weniger
Institut für Phytopathologie der Universität Kiel
D-2300 Kiel

Summary

Attempts to analyse the host selection patterns of *Asaphes* spp. are difficult because of their polyphagy. Females of *Asaphes vulgaris* and *Asaphes suspensus*, conditioned for two years on *Aphidius rhopalosiphi*, were first exposed to different possible selection factors before testing their preference between *Aphidius rhopalosiphi* (*Sitobion avenae*) and *Aphidius ervi* (*Acyrthosiphon pisum*).
The first generation of the *Asaphes* species reared on *A. ervi* was also tested.

While *Asaphes suspensus* was already stimulated by the host plant, both species accepted *A. ervi* better after previous feeding on this host. Obviously *Asaphes* spp. "learn" to accept a new host by host feeding. The first generation of *Asaphes* spp. reared on *A. ervi* showed a slight preference towards *A. ervi*.

In host selection tests of the conditioned *Asaphes* spp. between *A. rhopalosiphi* and *A. ervi*, both reared on *S. avenae*, *A.ervi* was still discriminated in a similar way as *A. ervi* in *Acyrthosiphon pisum*. Methanol extractions from empty *A. ervi* mummies, applied to mummies of *A. rhopalosiphi*, led to a refusion of the "strange smelling" mummy. The experiments indicate that semiochemicals, produced by the primary parasitoid in mummies, are percieved by the hyperparasitoids.

Introduction

The genus *Asaphes* (Hymenoptera: Pteromalidae) occurs late but in relatively large numbers in cereals (Jones 1979, Höller 1988). Two species are known: *Asaphes vulgaris* Wlk. and *Asaphes suspensus* (Nees). Both hyperparasitoids are ectophagous and polyphagous (Sullivan 1987).

In search of a possible manipulation of host acceptance by *Asaphes* spp., with the aim to minimize their negative effect on the cfficiency of primary parasitoids, host selection behaviour should be better understood. This study investigated the following questions:

a) could host selection be influenced by the effect of "associative learning", as it has been reported for braconids (Vinson et al. 1977, Dmoch et al. 1985) and ichneumonids (Arthur 1971),

b) which factors could be involved in this process and

c) may semiochemicals be involved in host acceptance by *Asaphes* spp.?

Methods

Asaphes vulgaris and *Asaphes suspensus* were collected from winterwheat and reared in the laboratory for two years on *Aphidius rhopalosiphi* De Stefani-Perez, with *Sitobion avenae* F. as host aphid and *Avena sativa* L. as host plant. Females examined in selection tests were kept as standard seven to ten days on their hosts from which they had emerged at a constant temperature of 20 $\pm$ 1.5°C and a L16:D8 light - dark regime.

The selection tests were performed in 35mm Petri dishes, in which a female hyperparasitoid was given the choice between two host species, each in three mummies. The number of attacks (perforation of the mummy with the ovipositor) within one hour was counted. In all tests thirty females of *Asaphes vulgaris* and twenty of the more active *Asaphes suspensus* were studied.

Selection tests of *Asaphes* spp. between *A. rhopalosiphi* (reared on *S. avenae* / *A. sativa*) and *A. ervi* (reared on *A. pisum* / *V. faba*) were carried out with:

1. females from *A. rhopalosiphi* cultures,

Table 1. Host selection of *Asaphes* spp. (reared for 2 years on *Aphidius rhopalosiphi* with the host aphid *Sitobion avenae* on *Avena sativa*) between *Aphidius rhopalosiphi* (*Sitobion avenae* as host aphid and *Avena sativa* as host plant) and *Aphidius ervi* (*Acyrthosiphon pisum* as host aphid and *Vicia faba* as host plant). For each replicate a female was offered 3 mummies per host species for one hour.

			selection test			
		3 days	mummies	attacked [1]	% attack on	
species	reared on	exposure to	offered	mummies	*A. rhopalosiphi*	*A. ervi*
Asaphes vulgaris	*A. rhopalosiphi*	*A. rhopalosiphi*-culture	180 (n=30)	53	82.4	17.6
	A. rhopalosiphi	saccharose (s) only		44	70.4	29.6
		Vicia faba and (s)		47	70.2	29.8
		parasitized *A. pisum* (*A. ervi*) on *Vicia faba*		46	69.6	30.4
		A. ervi mummies and (s)		65	52.3	47.7
	A. ervi [2]	*A. ervi* - culture		54	38.9	61.1
Asaphes suspensus	*A. rhopalosiphi*	*A. rhopalosiphi*-culture	120 (n=20)	46	67.4	32.6
	A. rhopalosiphi	saccharose (s) only		42	64.3	35.7
		Vicia faba and (s)		47	51	49
		parasitized *A. pisum* (*A. ervi*) on *Vicia faba*		38	52.6	47.4
		A. ervi - mummies and (s)		58	43.1	56.9
	A. ervi [2]	*A. ervi* - culture		39	43.6	56.4

1) mummies perforated with the ovipositor
2) first generation of *Asaphes* spp. on *Aphidius ervi*

2. females from *A. rhopalosiphi* cultures, exposed three days to:
   - saccharose solution (15%, in cotton wool) only in a Petri dish,
   - *Vicia faba* in a plexiglass tube (30cm x 10cm) with additional saccharose,
   - *Vicia faba* with parasitized, not yet mummified *A. pisum* (*A. ervi*) without additional saccharose,
   - mummies of *A. ervi* in a Petri dish with additional saccharose,
3. females developed in the first generation on *A. ervi.*

The selection of *Asaphes* spp. between *A. rhopalosiphi* and *A. ervi*, both reared on *S. avenae* / *A. sativa*, should provide an indication if the primary parastoid plays a role in the selection process. To test if semiochemicals emitted by the host may be involved, 100 empty mummies of *Aphidius ervi* (*Acyrthosiphon pisum*) were transferred each into Eppendorf reaction tubes and extracted with 100 µl methanol (99.8 %). After centrifugation at 12.000 rpm for 10 minutes, the supernatant was used: 1 µl was pipetted on each *A. rhopalosiphi* mummy. On the total 150 mummies were treated in this way. As control, the same number of *A. rhopalosiphi* mummies was treated with 1µl methanol (99.8 %) only.

In order to examine the antagonistic potential and life duration of both *Asaphes* species, thirty fresh mummies of *A. rhopalosiphi* were offered daily to a female in a Petri dish. Mummies from which no *Asaphes* offspring had emerged were dissected. Unhatched eggs of *Asaphes* spp. can easily be recognized, because their residue is still anchored in the deteriorated host. Mummies killed by oviposition can thus be distinguished from mummies killed by host feeding.

Results and discussion

The conditioning of *Asaphes vulgaris* on *A. rhopalosiphi* was reflected in a strong preference towards *A. rhopalosiphi* (Tab.1). It was, however, partially diminished, when, three days before the selection test, the females were exposed to saccharose only. Previous "experience" on the host plant of *A. ervi*: *Vicia faba* and the host aphid *A. pisum*, parasitized by *A. ervi*, still led to a discrimination of *A. ervi*. By contrast, attack rate on *A. ervi* was considerably increased, when *Asaphes vulgaris* was given the possibility to feed on *A. ervi* before. The first generation of *Asaphes vulgaris* reared on *A. ervi* preferred *A. ervi*.

Higher tolerance towards "strange" hosts, often observed in *Asaphes suspensus*, was also manifested in the test (Tab.1). *A. ervi* was more readily accepted as host, when *Asaphes suspensus* was previously exposed to *Vicia faba*. Honey dew released by parasitized *A. pisum* on the same plant had obviously no further effect on the attraction rate. Host feeding on *A. ervi* again enhanced host acceptance of this species. The first generation of *Asaphes suspensus* , reared on *A. ervi*, preferred *A. ervi* to a lesser degree than *Asaphes vulgaris.*

The low attack rate of the *Asaphes* species on *A. ervi* (Tab.2) indicates that the primary parasitoid is an important factor in host recognition. This is further supported by the fact that the strongest influence on the acceptance of the "new host" *A. ervi* was obtained after a prior contact with this host (Tab.1). Host acceptance by *Asaphes suspensus* after previous contact with the host plant *Vicia faba* only (Tab.1), without any experience on *A. ervi*, could be interpreted as stimulated searching behaviour.

Table 2. Host selection of *Asaphes* spp. (reared for 2 years on *Aphidius rhopalosiphi* with the host aphid *Sitobion avenae* on *Avena sativa*) between *Aphidius rhopalosiphi* and *Aphidius ervi* with the host aphid *S. avenae* on *A. sativa.* For each replicate a female was offered 3 mummies per host species for one hour.

species	mummies offered	attacked mummies	% attack on	
			A. rhopalosiphi	*A. ervi*
Asaphes vulgaris	180 (n=30)	60	63.3	36.7
Asaphes suspensus	120 (n=20)	40	77.5	22.5

The methanol extracts of empty *A. ervi* mummies, applied to the preferred *A. rhopalosiphi* mummies, led to an irritation of the hyperparasitoids (Tab.3). These results, as well as those represented in Table 2, indicate that semiochemicals, produced by the primary parasitoid within the mummies, are involved in the selection process.

Table 3. Host selection of *Asaphes* spp. (reared for 2 years on *Aphidius rhopalosiphi* with the host aphid *Sitobion avenae* on *Avena sativa*) between *Aphidius rhopalosiphi*, treated with 1 µl methanol (control) and *Aphidius rhopalosiphi*, treated with 1 µl methanol extract, derived from *Aphidius ervi* mummies. For each replicate a female was offered 3 mummies per host species for one hour.

species	mummies offered	attacked mummies	% attack on *A. rhopalosiphi*	
			methanol only	methanol extract
Asaphes vulgaris	180 (n=30)	44	70.5	29.5
Asaphes suspensus	120 (n=20)	39	69.2	30.8

Host feeding of *Asaphes lucens* (Provancher), which is presumably identical with *Asaphes suspensus* (Höller, personal communication), was described by Keller and Sullivan (1976). Its influence on the antagonistic potential of *Asaphes* spp. is impressing: one third of killed mummies are due to host feeding alone (Tab.4).

Table 4. Life duration of *Asaphes* spp., exposed to saccharose and 30 fresh mummies of *Aphidius rhopalosiphi* (renewed daily), and number of *A. rhopalosiphi*, killed by oviposition and host feeding alone.

species	mean life duration (days) (n=5)	no. of *A. rhopalosiphi* killed by		% host feeding
		oviposition and host feeding		
Asaphes vulgaris	46 (SD=9)	278 (SD=80)	144 (SD=34)	34.1
Asaphes suspensus	62 (SD=13)	440 (SD=74)	167 (SD=63)	27.5

The results of the selection tests in Table 1 indicate that host feeding plays an important role in the parasitic behaviour of these hyperparasitoids: they show an apparent change in attack behaviour due to experience, i.e. chemical and physical cues in host recognition by *Asaphes* spp. seem to be less determined by instinct than by associative learning. Feeding on the haemolymph of the host obviously overrides the repellent effect of the *A. ervi* semiochemicals. In the field it seems likely that the genus *Asaphes* concentrates on the most abundant host species. This behaviour has been termed "switching" by Murdoch (1969) and it can be expected that the two *Asaphes* species are not only able to switch between hosts in one, but also in different habitats.

Acknowledgements

I thank Prof. Dr. U. Wyss and Dr. C. Höller for comments.

References

Arthur, A.P., 1971. Associative learning by *Nemeritis canescens* (Hymenoptera: Ichneumonidae). Can. Entomologist **103**: 1137 - 1141.

Dmoch, J., Lewis, W.J., Martin, P.B. & D.A. Nordlund, 1985. Role of host-produced stimuli and learning in host selection behavior of *Cotesia* (=*Apanteles*) *marginiventris* (Cresson). J. of Chem. Ecol. **11(4)**: 453 - 463.

Höller, C., 1988. Effizienzanalyse der Parasitoiden an Getreideblattläusen. Dissertation Universität Kiel, 114 pp

Jones, M., 1979. Abundance of aphids on cereals from before 1973 to 1977. J. of appl. Ecol. **16**: 1 - 22.

Keller, L.J. & D.J. Sullivan, 1976. Oviposition behavior and host feeding of *Asaphes lucens* an aphid hyperparsitoid. New York Ent. Soc. **84 (3)**: 206 - 211.

Murdoch, W.W., 1969. Switching in general predators: experiments on predator specificity and stability of prey populations. Ecol. Monographs **39**: 335 - 354.

Sullivan, D.J., 1987. Insect hyperparasitism. Ann. Rev. Entomol. **32**: 49 - 70

Vinson, S.B., Barfield, C.S. & R.D. Henson, 1977. Oviposition behaviour of *Bracon mellitor*, a parasitoid of the boll weevil (*Anthonomus grandis*). II.Associative learning. Physiol. Entomol. **2**: 157 - 164

SURVEY FOR NATURAL ENEMIES OF DIURAPHIS NOXIA (MORDVILKO) IN EURASIA

F. GRUBER, T. J. POPRAWSKI and E. REY

UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE
INTERNATIONAL ACTIVITIES, EUROPEAN PARASITE LABORATORY
13-17 Rue de la Masse, F-78910, Orgerus-Béhoust, France

Summary

Diuraphis noxia (Mordvilko) (Homoptera: Aphididae) was detected in the Texas Pandhandle in March 1986. In less than four years, the "Russian wheat aphid" (RWA) has spread to 17 American States and 3 Canadian provinces located west of the 98th meridian. The economic loss resulting from RWA damage to wheat and barley in the United States alone has exceeded 200 million dollars in 1989. In 1988 and 1989, scientists from the European Parasite Laboratory (EPL) have collected parasitoids, predators and pathogens associated with RWA in Eurasia. Intensive field surveys in Turkey, Greece, Yugoslavia, Bulgaria, Morocco, Spain, southern France and the USSR (Moldavia, Crimea, Ukraine and Kirgizia) have resulted in the recovery of several species of parasitoids including *Aphelinus* sp., *A. asychis* Walker, *A. varipes* Foerster, *Aphidius* sp., *A. matricariae* Haliday, *A. rhopalosiphi* De Stefani, *A. uzbekistanicus* Luzhetski, *Diaeretiella rapae* M'Intosh, *Ephedrus plagiator* Nees, *Praon* sp., *P. necans* Mackauer and *P. volucre* Haliday. Predators included *Adonia (Hippodamia) variegata* (Goeze), *Coccinella septempunctata* L., *Chrysopa carnea* Stephens, *Hippodamia tredecimpunctata* L., *Leucopis* sp., *Propylea quatuordecimpunctata* L., *Scymnus* sp., *S. ater* (F.), *S. frontalis* F. and *Thea vigintiduopunctata* L. Syrphidae, Staphylinidae and Chamaemyiidae were also recovered from RWA-infested plants but attempts to rear them failed. *Conidiobolus obscurus* (Hall & Dunn) Remaudière & Keller, *Entomophthora planchoniana* Cornu, *Pandora neoaphidis* (Remaudière & Hennebert) Humber, *Neozygites fresenii* (Nowakowski) Remaudière & Keller and *Zoophthora radicans* (Brefeld) Batko were among the entomopathogenic fungi isolated from *D. noxia*. The predators and parasitoids found associated with RWA were freed of unwanted organisms, increased in numbers and subsequently shipped to the United States for mass production and field releases. Further surveys to collect more entomophages of RWA are planned in various regions of Eurasia including Iran, Iraq, Pakistan, Afghanistan, Yugoslavia, Turkey, France, Greece, Morocco, Tunisia, the Transcaucasus, northwestern China and the Soviet Central Asia.

1.1 Introduction

The Russian wheat aphid, *Diuraphis noxia*, has been described by Mordvilko (1914) from specimens collected during massive outbreaks in the small grain-growing plains of the Ukraine.

RWA is believed to originate from the Transcaucasus or/and the Tien Shan and it probably spread to its present Eurasian range with caravans. Although outbreaks of RWA occurred in Anatolia in the early 1960's (M. Oner and C. Oncüer, pers. commun.), at present the aphid is only a sporadic pest of wheat and barley in the Mediterranean, Black and Caspian Sea basins, and the Soviet Central Asia including the Tien Shan mountains. It is believed that RWA is rarely an important pest in Eurasia because of a combination of limiting factors including tolerant host plants, geoclimatic conditions and especially well-adapted natural enemies. Recently however, RWA has increased its distribution range to new regions of the world in which it quickly became the most important pest of small grains. Detected in the Orange Free State in the spring of 1978, D. noxia had migrated to virtually every wheat-growing area of South Africa by 1981 (Walters et al. 1980). Previously unobserved symptoms of damage by RWA were observed in Mexico in 1980 and, two years later, RWA was widely distributed in cereals on the Central Plateau, and in the Toluca and Saltillo regions in 1983 (Gilchrist et al. 1984). In 1986 the aphid was found in the Texas Pandhandle and, in less than four years, it has spread to 17 American States and 3 Canadian provinces (Lesser and Morrison 1986, Stoetzel 1987, Halbert et al. 1988, Jones et al. 1989). In general, D. noxia has prospered in semi-arid, dryland wheat regions, and its North American distribution range appears to be limited to the west of the 98th meridian.

Control of RWA at present centers largely on the use of insecticides but long term management approaches are desired, including host plant resistance and biological control (Burton 1988). Efforts to identify natural enemies associated with RWA have been undertaken in USSR (Berest 1980), South Yemen (Erdelen 1981, Stary and Erdelen 1982), Ethiopia (Haile and Megenasa 1987) and South Africa (Aalbersberg et al. 1988, Hughes 1988). Laboratory studies in the United States have indicated that two native parasitoids species, Lysiphlebus testaceipes Cresson (Aphidiidae) and Aphelinus varipes Foerster (Aphelinidae) are poorly adapted to RWA (Gilstrap and McKinnon 1988).

In March 1988, the European Parasite Laboratory has therefore redirected some of its foreign exploration to include the RWA and its natural enemies. As a result of these efforts, biological control of the aphid has been and is being a research area with encouraging results. Explorers searching for biocontrol agents of the pest have been successful in finding promising biomaterial in Eurasia. The findings of the EPL and of its cooperators are reported herein.

1.2 Methods

1988 - The search for RWA and its natural enemies was originally scheduled for southwestern USSR but the small grain growing season was too far advanced in May to complete arrangements for exploratory field work. Surveys were then shifted to southeastern Europe and Turkey because D. noxia had been recorded in the region of Sofia (D. Kontev, person. commun.) and the areas of Egredir, Malatya, Ankara and Konya (C. Oncüer and M. Oner, person. commun ; Tuatay and Remaudière 1964) and because Turkey is believed to be part of the aboriginal home of the aphid (V. Eastop, person. commun.).

FG and TJP searched for D. noxia in Yugoslavia, Greece, Bulgaria, western Turkey and central Anatolia during May 9 to June 1. K. Carl (Commonwealth Institute for Biological Control) and V. Eastop (British Museum) searched for the aphid from May 22 to June 2 in sites of western and central Turkey not explored by FG and TJP, and in southeastern Turkey near the Syrian border. FG and TJP returned to western Turkey during June 14-19. This cooperation made it possible to discover the pest and several of its biotic control agents in the first season of a new program which is considered unusual in this type of research.

FG collected cereal aphids and their enemies in the French Drôme and Vaucluse departments on two occasions: July 5-7 and August 2-5.

R. Carruthers (US Department of Agriculture) and TJP surveyed western Turkey again in early September.

1989 - FG and R. Bennett (US Department of Agriculture) searched barley and wheat fields in northern and central Spain from March 28 to April 7.

A. Sekkat (Ecole Nationale d'Agriculture de Meknès, Morocco) and R. Miller (International Center for Agricultural Research in the Dry Areas, Alepo, Syria) informed the EPL that RWA had been detected in February 1989 near Settat and Meknès, Morocco. FG and G. Mercadier (EPL) thus searched the northern slope of the middle Atlas during April 21 to 30.

Strategies developed by the Agricultural Research Service of the US Department of Agriculture for exploring in a rational manner included international cooperative efforts which climaxed, in 1989, in the establishment of the first Joint US-Soviet Biocontrol Laboratory at Kishinev, Moldavian SSR.

FG, TJP and I. Kiriac (All-Union Research Institute of Biological Methods in Agriculture, Kishinev) surveyed Moldavia for RWA during May 25 to June 15 under the auspices of the joint US-USSR program.

In mid-July, Kiriac searched the region of Kishinev where he had detected RWA in 1982.

Southern France was added to the list warranting exploration on the basis of the information received from French entomologists. Mercadier and K. Hopper (EPL) surveyed small grain fields in the Antibes area and the Alpes Maritimes from June 5 to 9 and again from June 19 to 22. FG explored the Alpes Maritimes and Hautes Alpes during July 3 to 8.

TJP and Kiriac surveyed the Tien Shan range of the Kirghiz SSR from August 15 to September 16.

A second exploration of the Moldavian SSR and a first visit to southern Ukraine including the Crimean Peninsula were made from October 21 to November 8 by FG, Kiriac and S. Halbert (University of Idaho).

1.3.1 Results of surveys (Tables 1 to 3)

1988 - RWA were not found in Yugoslavia, Greece nor Bulgaria.

The first expedition to Turkey (TJP and FG) was unsuccessful. Although not detected by them in southern Turkey, Eastop and Karl found RWA but no natural enemies in a few fields along the transect Sivas-Ankara-Ayas-Beypazari. Visual inspection of wheat (at Ayas) and barley (at Beypazari) by TJP and FG (second trip to Turkey) resulted in the recovery of RWA and natural enemies, including the predatory larvae of Chrysopidae, Syrphidae, *Scymnus* spp. (Coccinellidae) and *Leucopis* spp. (Chamaemyiidae), and the adults of the coccinellids *Scymnus frontalis*, Adonia variegata and Propylea 14-punctata. Ephedrus plagiator, Aphelinus spp., Aphelinus varipes, Aphidius sp., Aphidius matricariae, A. rhopalosiphi and A. uzbekistanicus were among the species recovered from parasitized D. noxia nymphs and adults. Aphidius spp. were also recovered from the cereal aphids Sipha (Rungsia) sp., Rhopalosiphum maidis Fitch and Sitobion avenae F. found on plants infested with D. noxia. The latter parasites were collected because their hosts generally occur in mixed populations in the fields and because of their apparent broad host range in the small grain ecosystem.

Table 1. Primary parasites of D. noxia recovered in 1988-1989

Location and date	Number of aphids collected	Number of parasites*				
		Aphelinus	Aphidius	Diaeretiella[g]	Ephedrus	Praon
1988						
Turkey						
June	2000	71[b]	43[cdef]	-	2[h]	-
1989						
Morocco						
April	20	-	-	-	-	-
Moldavia						
May-June	1000	30[b]	50[f]	-	-	4[i]
France						
June	1675	23[ab]	80[f]	70	-	-
France						
July	140	3[a]	5[ef]	4	1[h]	2[j]
Kirghizia						
Aug-Sept.	969	25[b]	58[f]	4	-	-
Ukraine						
Oct.-Nov.	163	4[b]	-	5	-	1[j]

[a] asychis, [b] varipes, [c] matricariae, [d] rhopalosiphi,
[e] uzbekistanicus sp., [f] Aphidius sp., [g] rapae, [h] plagiator,
[i] necans, [j] volucre.
* Number of viable adults that emerged in the laboratory, not number of mummies collected in the field.

Along this line, FG's two surveys in the Drôme and Vaucluse French departments yielded the cereal aphid parasites Aphidius spp., Praon gallicum Stary, Ephedrus plagiator and A. varipes. All parasites recovered from cereal aphids other than RWA were multiplied on RWA at the EPL before shipment to the US. Coccinella 7-punctata (pupae), Scymnus ater and S. ferrugatus (larvae and adults), Adalia bipunctata and Propylea 14-punctata (adults) were among the coccinellids collected during FG's surveys in France.

Diuraphis noxia was not recovered from stubble nor from dried-out wild Poaceae searched by TJP and R. Carruthers at Beypazari and Ayas in early September.

1989 - Although D. noxia had been recorded in several regions of Spain (Castanera and Santiago 1983; J. M. Nieto Nafria and X. Pons, pers. commun.), FG and R. Bennett found no RWA during extensive searches in northern and central Spain. Aphidius spp. and Ephedrus plagiator recovered from Sitobion avenae and Metopolophium dirhodum (Walk.) did not accept RWA as a host in a series of laboratory trials.

A few unparasitized RWA were collected in late April from winter wheat in the Settat area (Morocco). Over 95% of these aphids subsequently died from fungal infection (Pandora neoaphidis) in the laboratory. The collapse of field populations of RWA observed in April apparently resulted from the heavy rains of March. No RWA were found in Spain on the return trip to the laboratory.

Table 2. Predators of Diuraphis noxia recovered in 1988-1989

Location and date	Number of predators a	b	c	d	e	Scymnus	Other
1988							
Turkey	-	14	21	-	15	17[f]	Leucopis
1989							
Moldavia	210	81	13	12	-	-	Syrphidae, Chrysopidae
France	37	22	5	-	-	-	Scymnus larv. Syrp., Chrys.
Kirghizia	207	580	-	28	-	-	Syrphidae
Crimea	28	8	8	21	7	-	Chamaemyiidae

[a] Coccinella septempunctata, [b] Adonia variegata, [c] Propylea quatuordecimpunctata, [d] Hippodamia tredecimpunctata, [e] Thea vigintiduopunctata, [f] Scymnus frontalis.

RWA and its enemies were found in the vicinity of the Moldavian southern towns of Komrat, Suvorovo, Tchadyn-Lunga, Dubossory and Grigoriopol, and sporadically in the Soroki and Edintski regions in the north of the republic. Mummies of Praon necans, P. volucre, Aphelinus sp. (probably varipes), Ephedrus sp. and Aphidius spp. (probably rhopalosiphi and uzbekistanicus) were collected from RWA-infested plants. Between 80% and 95% of these mummies were hyperparasitized. The viable primary parasites that emerged in the laboratory are accounted for in Table 1. Adonia variegata, C. 7-punctata, P. 14-punctata and H. 13-punctata were found associated with D. noxia.

RWA-infested experimental fields located some 10 km NE of Antibes, France, yielded A. asychis, A. varipes, D. rapae and Aphidius sp. Pandora neoaphidis was also isolated from RWA during the two June surveys in southeastern France. Diaeretiella rapae, E. plagiator, P. volucre, A. asychis, Aphidius sp. and A. uzbekistanicus were reared from RWA found by FG during his July visit to barley fields in the French Hautes Alpes and Alpes Maritimes (Tables 1 and 3). Coccinella 7-punctata, H. variegata, P. 14-punctata, larvae of syrphid flies and Entomophthorales were commonly found during these three surveys.

High populations of RWA were observed in several localities of the Kirghiz Tien Shan range, including Naryn, Chaek, Iachmen, Min-Kouch, Mink-Boulak and Kochkorka. Aphelinus varipes, Aphidius sp. and D. rapae were reared from mummified RWA. No entomophthorales were found but C. 7-punctata, H. variegata and H. 13-punctata appeared to be the key control agents of the pest in the adverse environment of the Soviet Central Asian republic.

Only light infestations of RWA in winter wheat and volunteer grain were observed in autumn in Moldavia (Komrat, Surovoro), southern Ukraine (Kherson and Odessa) and Crimea (Simferopol). A few specimens of A. varipes, D. rapae and Praon sp. were obtained from RWA collected in Crimea. Five species of coccinellids and unidentified chamaemyiid larvae were found in the Crimean fields (Table 2).

During 1989 the EPL also received D. rapae, Aphidius colemani Viereck and Praon sp. obtained from RWA by Miller in Syria (May), and Aphidius sp. and larvae of Leucopis recovered from RWA-infested plants by K. Pike and L. Tanigoshi (Washington State University) in Jordan (early June).

Table 3. Primary parasites of Diuraphis noxia collected in southeastern France, 1989

Location and date	Altitude (m)	Host plant	Parasite species
Antibes 6/6	7	wheat	A. asychis, A. varipes D. rapae
Seranon 6/7	1092	barley	A. asychis
Aspremont 6/8	780	barley	A. asychis, D. rapae
Antibes 6/20	7	wheat	A. asychis, A. varipes D. rapae
St. Vallier 7/5	764	barley	Aphidius sp., P. volucre
Malamaire 7/5	1044	barley	none
Gréolières 7/5	1150	barley	none
Veynes 7/6	875	barley	Aphidius sp.
Aspremont 7/7	780	barley	Aphidius sp., E. plagiator

1.3.2 Shipments

Predators and parasites collected during the surveys were hand-carried or shipped to the EPL where they were quarantined and freed of any unwanted organisms. They were multiplied on RWA and finally shipped to various American governmental and university biocontrol laboratories for further multiplication, biological control studies and release in RWA-infested cereal fields. Shipments of RWA natural enemies made by the EPL in 1988-1989 are summarized in Table 4.

Table 4. Summary of shipments of *D. noxia* natural enemies, 1988-89

Species shipped	Origin	Number shipped[a]
PREDATORS		
Adonia variegata	Turkey, France, Moldavia, Crimea, Kirgizia	719
Coccinella 7-punctata	Crimea, Kirgizia, France, Moldavia	482
Propylea 14-punctata	Crimea, France, Moldavia, Turkey	161
Thea 22-punctata	Crimea, Turkey	22
Hippodamia 13-punctata	Crimea, Kirgizia, Moldavia	61
Chrysopa carnea	Jordan	30
Scymnus ater	France	2
Scymnus (ferrugatus?)	France	7
Scymnus sp.	France	17
Leucopis sp.	Turkey	9
PARASITES		
Praon necans (abjectum?)	Moldavia	49
Praon (gallicum?)	France	132
Praon volucre	France, Turkey	1116
Ephedrus plagiator	France, Turkey	2344
Aphelinus (varipes?)	France	43
Aphelinus asychis	France	3645
Aphelinus (asychis?)	Moldavia	1048
Aphelinus sp.	Turkey	263
Aphidius (Diaeretiella?)sp.	France	752
Aphidius sp.[b]	Kirgizia, France, Turkey, Moldavia	4882
Diaeretiella rapae	Crimea, France, Syria, Kirgizia	3316

[a] Combined for the two years of the surveys.
[b] Specimens identified after shipment as *Aphidius* sp., *A. matricariae*, *A. rhopalosiphi* and for *A. uzbekistanicus*.

REFERENCES

AALBERSBERG, Y. K., Van der WESTHUIZEN, M. C. and HEWITT, P. H. (1988). Natural enemies and their impact on Diuraphis noxia (Mordvilko) (Hemiptera: Aphididae) populations. Bulletin of Entomological Research 78: 111-120.

BEREST, Z. L. (1980). [Parasites and predators of the aphids Brachycolus noxius and Schizaphis graminum in crops of barley and wheat in Nikolaev and Odessa regions]. Vestnik Zoologii 2: 80-81. (in Russian)

BURTON, R. L., compiler (1988). The Russian wheat aphid. First Annual Report of the Agricultural Research Service, U. S. Department of Agriculture.

CASTANERA, P. and SANTIAGO, C. (1983). [Study on the aphid-parasitoid (Homoptera: Aphidoidea; Hymenoptera: Aphidiidae) relationship, in the Iberian Peninsula]. Actas del Primer Congreso Iberico de Entomologia, Leon, Espana (7-10 Junio): 149-157. (in Spanish)

ERDELEN, C. (1981). [The aphid fauna of the Arab Republic of Yemen, with special regard to the most important species on cereals]. Dissertation, University of Bonn. (in German)

GILCHRIST, L. I., RODRIGUEZ, R. and BURNETT, P. A. (1984). The extent of Freestate streak and Diuraphis noxia in Mexico, pp. 157-163. In Barley Yellow Dwarf: Proceedings of the Workshop sponsored by the United Nations Development Programme and CIMMYT, 6-8 Dec. 1983, CIMMYT, Mexico.

GILSTRAP, F. E. and McKINNON, L. K. (1988). Response of native parasites to Russian wheat aphid. Texas Agricultural Experimental Station Publication PR-4558.

HAILE, A. and MEGENASA, T. (1987). Survey of aphids on barley in parts of Shewa, Welo and Tigrai, Ethiopia. Ethiopian Journal of Agricultural Sciences 9: 39-53.

HUGUES, R. D. (1988). A synopsis of information on the Russian wheat aphid, Diuraphis noxia (Mordwilko). Division of Entomology, CSIRO Technical Paper 28.

JONES, J. W., BYERS, J. R., BUTTS, A. and HARRIS, J. L. (1989). A new pest in Canada: Russian wheat aphid Diuraphis noxia (Mordvilko), (Homoptera: Aphididae). Canadian Entomologist 21: 623-624.

LESER, J. F. and MORRISON, W. P. (1986). Texas Agricultural Extension Service, Focus on Entomology 21.

STARY, P. and ERDELEN, C. H. (1982). Aphid parasitoids (Hymenoptera: Aphidiidae, Aphelinidae) from North Yemen. Entomophaga 27:105-108.

STOETZEL, M. B. (1987). Information on and identification of Diuraphis noxia (Homoptera : Aphididae) and other aphid species colonizing leaves of wheat and barley in the United States. Journal of Economic Entomology 80: 696-704.

TUATAY, N. and REMAUDIERE, G. (1964). Première contribution au catalogue des Aphididae (Hom.) de la Turquie. Revue de Pathologie Végétale et d'Entomologie Agricole de France 43: 243-278.

WALTERS, M. C., PENN, F., DU TOIT, F., BOTHA, T. C., AALBERSBERG, K., HEWITT, P. H. and BROODRYK, S. W. (1980). The Russian wheat aphid. Farming in South Africa, Leaflet Series: Wheat C3.

INFLUENCE OF PESTICIDES ON THE EPIGEAL ARTHROPOD FAUNA IN LABORATORY TESTS

R.DE CLERCQ, H. CASTEELS and J. JANSSENS
State Nematology and Entomology Research Station
(C.L.O. - Gent) Merelbeke, Belgium

Summary

Five insecticides (parathion, dimethoate, phosalone, fenvalerate and pirimicarb) and three fungicides (propiconazole, fenpropimorph and prochloraz) were tested under laboratory conditions for their side effects on carabids and spiders. Parathion and dimethoate show a very toxic effect on the carabids and spiders. Other tested pesticides show also a negative effect on the investigated beneficial organisms.

1. Introduction

Since 1960 the increasing abundance of aphids in winter wheat, has resulted in almost regular insecticide treatments, which has been developed in order to prevent severe yield loss, and this without considering the natural ennemies of the aphids.

However, in recent years, many studies have proved the importance of predators and parasites in reducing cereal aphid numbers; in this group of beneficial organisms the so-called polyphagous predators (Carabidae, Staphylinidae and Araneae) are very important in annual crops, because they can feed on a wide variety of foods, but will switch to eating aphids, whenever they have the opportunity.

In different field experiments in winter wheat we have already investigated the influence of the commonly used insecticides (parathion, dimethoate, pirimicarb, phosalone and fenvalerate) and fungicides (benomyl, fenpropimorph, prochloraz and propiconazole) on the polyphagous predators (3).

This paper describes analogous experiments, carried out under laboratory conditions.

2. Material and methods

The initial toxicities of 5 insecticides (parathion, dimethoate, phosalone, fenvalerate and pirimicarb) and 3 fungicides (propiconazole, fenpropimporph and prochloraz), commonly used in winter wheat, are investigated on 5 carabids (Bembidion lampros

Herbst, Asaphidion flavipes L. Pterostichus melanarius Illiger, Platynus dorsalis Pontoppidan and Amara similis Gyllenhal) and 4 spiders (Erigone atra Blackwall, Bathyphantes gracilis Blackwall, Leptyphantes tenuis Blackwall and Oedothorax apicatus Blackwall) with a laboratory method (2,4, 5, 6).

The test cages are plastic petri-dishes (diameter 87 mm, height 16 mm) with a gauze-covered ventilation hole, 37 mm in diameter, on the top, while the bottom of the dishes has a circular gauze-covered hole in the centre, 60 mm in diameter. The test cage is filled with ± 30 gram dried pebble-stones (1-4 mm).

The petri-dishes are moistened by drenching for 1 second in a solution of the investigated pesticide at the recommended concentration for practical use. The untreated control cages are drenched in water for one second. The test cages are then dried at room temperature during 24 h.

We obtain an even pesticide layer on the pebble-stones by drenching the bottom part of the cage for one second in a solution of the tested pesticides with following concentrations :

Active ingredient	Concentration (%)
parathion	0,02
dimethoate	0,02
pirimicarb	0,05
phosalone	0,25
fenvalerate	0,007
propiconazole	0,07
fenpropimorph	0,2
prochloraz	0,1

The beneficial organisms are collected in the field by pitfall trapping; the captured carabids and spiders are held in plastic boxes, placed in a dark, cold room (± 5°C). They are fed with aphids and larvae of the house-fly and provided with water. Organisms held under these conditions can survive for up to four months with little mortality. The beneficials are acclimatised in the laboratory for at least 72 h prior testing.

The beneficials are then transferred to the test cages (5 individuals each) in three replications and exposed to the freshly dried pesticide film on the little stones. For testing the initial toxicities of pesticides on Araneae, only one spider per test cage (15 replications) was used.

After applying the pesticides the cages were placed on moistened filter paper, supplying extra water for the beneficials. Food was given to the beneficial organisms every two days.

One, three, six and nine days after introduction in the test cage, the number of dead predators were counted.

3. Results

The results of these laboratory tests are given in tabel I, II, III and IV

Table I : Side effects of five insecticides and three fungicides on a total of 5 tested carabid species, exposed to the residual action during several days

Treatment	Mortality (in %) after :			
	1 day	3 days	6 days	9 days
Untreated	0	3	12	24
Parathion	100	100	100	100
Dimethoate	91	95	95	97
Phosalone	37	84	99	99
Fenvalerate	17	68	81	88
Pirimicarb	40	65	73	76
Propiconazole	39	68	71	71
Fenpropimorph	69	81	84	84
Prochloraz	27	39	46	50

Table II : Mortality (in %) of five insecticides and three fungicides on 5 carabid species after one (a) and three (b) days.

Treatment		Bembidion lampros	Asaphidion flavipes	Pterostichus melanarius	Platynus dorsalis	Amara similata
Untreated	a	0	0	0	0	0
	b	0	13	0	0	0
Parathion	a	100	100	100	100	100
	b	100	100	100	100	100
Dimethoate	a	100	100	100	93	60
	b	100	100	100	100	73
Phosalone	a	0	27	7	50	100
	b	67	67	87	100	100
Fenvalerate	a	13	0	7	67	0
	b	100	80	20	100	40
Pirimicarb	a	73	7	0	93	27
	b	100	33	0	100	93
Propiconazole	a	20	80	33	50	10
	b	80	87	53	100	20
Fenpropimorph	a	100	73	0	80	90
	b	100	80	33	93	100
Prochloraz	a	87	7	13	20	10
	b	100	13	27	47	10

Table III : Side effects of three insecticides and one fungicide on a total of 4 tested spider species, exposed to the residual action during several days.

Treatment	Mortality (in %) after			
	1 day	3 days	6 days	9 days
Untreated	5	9	24	33
Pirimicarb	11	36	70	87
Dimethoate	30	64	93	98
Parathion	31	82	97	100
Propiconazole	0	3	24	46

Table IV : Mortality (in %) of three insecticides and one fungicide on 4 spiders species after one (a) and three (b) days

Treatment		Erigone atra	Bathyphantes gracilis	Leptyphantes tenuis	Oedothorax apicatus
Untreated	a	0	0	8	12
	b	0	7	12	16
Pirimicarb	a	0	30	12	0
	b	20	70	44	10
Dimethoate	a	13	70	17	20
	b	40	90	50	75
Parathion	a	27	70	12	13
	b	93	90	72	73
Propico-	a	0	0	0	0
nazole	b	0	0	0	10

4. Discussion and conclusion

4.1. Carabidae

- The results in table I demonstrate that dimethoate and parathion are most toxic and cause a reduction of the number of carabids after being exposed one day to the residues respectively for 91 % and 100 %. Analogous results were obtained by BASEDOW (1).

- One day after introduction of the beneficials the other insecticides pirimicarb, phosalone and fenvalerate cause a smaller reduction of the number of carabids by 40 %, 37 % and 17 % respectively.
- The toxic side effect of the fungicide fenpropimorph (reduction by 69 % after one day) is much larger than the toxic action caused by the other fungicides propiconazole (39 %) and prochloraz (27 %).
- After being exposed nine days to the respective residues, only prochloraz seems to have a little toxic side effect on the Carabidae fauna.
- Taking into account the different species separately (Table II) we can conclude that the side effects of the investigated insecticides and also of the fungicides differ from species to species
  Pterostichus melanarius is the least sensitive species.

4.2. Araneae

- Parathion and dimethoate show a slower action for spiders than for carabids; they cause a reduction of the number of spiders by 30-31% and 98-100%, after being exposed respectively one and nine days to the pesticide residues (Table III).
  Pirimicarb also is toxic for the spiders.
- The fungicides can also cause negative side effects on the spiders.
- Taking into account the different species separately (Table IV), we can conclude that Bathyphantes gracilis is more sensitive for the most tested pesticides.

References

1. BASEDOW, T. (1987)
   Der Einfluss gesteigerter Bewirtschaftungsintensität im Getreidebau auf die Laufkäfer (Coleoptera, Carabidae).
   Mitt. Biol. Bundesanst., Land-Fortwirtsch.Berlin-Dahlem H 235 : 1-123.
2. CHIVERTON PH.(1988)
   Laboratory method for testing initial toxicities of pesticides to the carabid Bembidion lampros.
   Bulletin SROP/OILB, XI/4 : 107-110.
3. DE CLERCQ R. and CASTEELS H. (1988)
   On the influence of some insecticides and fungicides on the epigeal arthropod fauna in winter wheat.
   Proceedings of a Meeting of the ECE, Littlehampton, 25-27 November 1986, 167-170.
4. HASSAN, T. (1985)
   Standard methods to test side effects of pesticides on natural ennemies to insects and mites developed by the IOBC/WPRS Working Group "Pesticides and Beneficial arthropods.
   EPPO Bull. 15 : 214-255

NITROGEN, PLANT GROWTH REGULATORS, PESTS AND DISEASES, AND THE ECONOMY OF GROWING WINTER WHEAT IN NORTHERN GERMANY

TH. BASEDOW

Institute of Phytopathology and Applied Zoology, Justus-Liebig-University, Ludwigstr. 23, D-6300 Giessen
and

A. AL-NAJJAR

P. O. Box 3307, Damaskus, Syria

SUMMARY

Field experiments on the economy of growing winter wheat (with oilseed rape as pre-crop) on sandy loam in Schleswig-Holstein were performed from 1982 to 1985 at 4 locations near Kiel (FRG) on plots of 12 x 200 m with 3 replicates. Additional special experiments took place on smaller plots of 12 x 12m, with 4 or 6 replicates. The occurrance of wheat diseases and of insect pests was measured weekly. The only insects of economic importance occurring were the cereal aphids. They showed an higher attack, the higher the amount of N-fertilizer given was (not significant). Chlormequat, in the field, did not reduce the attack of wheat by cereal aphids significantly; in 2 of the 4 experiments, the attack by the aphids was even slightly higher in plots treated with chlormequat. In 7 experiments, fungicidal treatments were effective against mildew in 4, against Septoria nodorum in 3, against eyespot in only two cases. The take-all-disease was not influenced by any treatment. Cereal aphid control proved to be necessary and effective in 6 of 7 experiments. Grain yields were lowest at the lowest intensities, but only in 3 of 7 experiments highest at the highest intensity. Net outputs were highest at reduced nitrogen levels with full pesticide input. It is shown, that a reduction of nitrogen input helps to reduce pesticide input. The environmental importance of the findings is discussed.

1. Introduction

Wheat is one of the most profitable agricultural crops, and farmers try to achieve maximum yields. To maximize it, a great amount of chemicals is used (nitrogen and pesticides), which have partly been shown to have undesirable environmental effects. Since the monetary input in growing wheat intensely has increased considerably, farmers are more engaged in regarding the net output of wheat production. But a comparism between different intensities is seldomly performed. So, from 1982 to 1985 we have performed field experiments in Schleswig-Holstein (FRG), to study the effects of the high chemical input on pests and diseases and on the economy of growing winter wheat (AL-NAJJAR et al. 1989, BASEDOW et al. 1990). The main results are shown and discussed here.

2. Study areas and methods

Studies took place near Kiel, in the district of Plön, at Passade, Lutterbek, Ratjendorf and Heikendorf, in even fields of winter wheat grown on sandy loam with winter oilseed rape as previous crop. Plots of 12 x 200m with 3 replicates were subjects of different treatments as shown in Tab.1.

Table 1: Variables of the field experiments in winter wheat. All plots received an herbicidal treatment in spring. The sites lay east of Kiel (district of Plön)

Variable	N (kg/ha)	Fungi-cides	Chlor-mequat	Insecti-cide	Performed at[1] in year
I	220-280	max.	+	+	P 1982/83/84 L 1983/84 R 1983/84, H 1985
II	195-225	max.	+	+	P 1982/83/84 L 1983/84 R 1983/84 H 1985
III	195-225	red.	reduced	0	P 1983/84 L 1983/84 R 1983/84 H 1985
IV	150	0	0	0	P 1982/83/84 H 1985

1) P = Passade, L = Lutterbek, R = Ratjendorf, H = Heikendorf

Insect pests were counted weekly on 100 tillers per plot. Only the cereal aphids (Hom., Aphididae) were occurring in important numbers. Diseases of wheat were recorded weekly on 45 tillers per variable, which were taken to the lab. The degree of attack was recorded according to a scale 1-9, with 1 = free of attack and 9 = highest possible attack.
Plots were harvested at the same time as the whole fields, leaving 1,5 m of the plots' margins apart. Grain yields were weighed at once, together with the determination of the water content of the grains. So yields per ha at 16 % of humidity could be calculated.
Net outputs were calculated on the base of the grain yields, the actual wheat prices and the actual costs of fertilizing and of plant protection, including application costs.
For testing the effects of nitrogen fertilizer and of chlormequat on cereal aphids, smaller plots were used (12 x 12 m), with 4 to 6 replicates.

3. Results

3.1 Nitrogen and cereal aphids

Nitrogen fertilizers have been shown to be possibly one of the reasons for the increasing importance of the cereal aphids (HINZ & DAEBELER 1976, HANISCH 1980 and HANSEN 1986). But in the field, the stimulating effect of nitrogen on the population growth of aphids was not always clear (HANSEN 1986). In our experiments, increasing the amount of nitrogen was followed by a tendency of the aphids'increased population growth (Table 2).

Table 2: The maximum (and relative) numbers of cereal aphids on small plots of winter wheat ("Kanzler") with different amounts of nitrogen fertilizers given. Heikendorf/Kiel (FRG), 1984 and 1985. In 1984, 90 % of the aphids were *Sitobion avenae* and 10 % *Metopolophium dirhodum*. In 1985, each of the 2 species represented 50 % of all aphids.
./. = not studied in 1984

year	maximum number of cereal aphids per 100 ears and flag-leaves (EC 75/85)		
	150 kg/ha N	200 kg/ha N	250 kg/ha N
1984	3718 (100%)	4080 (110%)	./.
1985	4244 (100%)	4442 (105%)	4805 (113%)

3.2 Chlormequat and cereal aphids

The amount of nitrogen fertilizer given to wheat can be increased, if the stems have been stabilized with a growth regulator, most commonly chlormequat. This compound has been shown to decrease cereal aphid numbers (HINZ et al. 1976, FRITZSCHE & THIELE 1979). Four experiments, performed by us, 1983-1985, showed contradictory, not significant results (Table 3): in 2 trials, aphid numbers increased slightly after the application of CCC, in futher 2 trials they decreased.

Table 3: The maximum attack by cereal aphids of winter wheat plots near Kiel, treated or not with chlormequat

year	location	variety	kg/ha N	g a.i./ha chlorme-quat (mid of April)	maximum number of cereal aphids per ear and flag leaf (EC 75/85)	
					With CCC	Without
1983	Passade	Disponent	195	920	1869	1704 (- 9%)
	Ratjendorf	Monopol	225	1150	2453	3334 (- 36%)
1984	Heikendorf	Kanzler	200	1150 +230 1380	875	1132 (+ 30%)
1985	Heikendorf	Kanzler	200	1150 +230 1380	1111	1021 (- 8%)

So, the performance of the effects of N or CCC on cereal aphids is not stable.
But the tendency seems prevailing, that aphid numbers increase with the increasing use of nitrogen fertilizers.

3.3 Growing intensity, wheat diseases, aphids, yields and net outputs

The results of 7 experiments are summarized in Table 4. The application of fungicides proved to be not very effective: mildew (*Erysiphe graminis*) was controlled sufficiently in 4 of 7 trials, *Septoria nodorum* in 3 of 7 cases, eyespot (*Pseudocercosporella herpotrichoides*) in only 2 of 7 cases, and take-all (*Gaeumannomyces graminis)* - as expected - in no case.
Cereal aphid control proved to be necessary and effective in 6 of 7 cases. No other insect pests occurred in important numbers.
Grain yields proved to be lowest in the variables of lowest intensity (III and IV). But the highest input (var. I) gave in only 3 of 7 experiments the highest yield (not significant); in the other 4 cases the variable II gave the highest grain yields (partly significant). Concerning the net outputs (gross margins) the variables III and IV were lowest, and II highest (nit var. I).
Since there did not exist any difference between var. I and II concerning pesticide input (Tab. 1) or the attack by pests and diseases (Tab. 4), the reason for the observed differences must be seen in the different amount of fertilizer given. With other words: The amount of N given to the plots of var. I was too high to be economic, it was uneconomic. This is important to note, since many farmers in Northern Germany still apply more than 220 kg/ha N (up to 300 kg/ha) to winter wheat. The problems arising from this are shown below.

Table 4: The maximum attack by fungal diseases and cereal aphids of winter wheat grown on large plots near Kiel (FRG), 1982-84, and the respective yields and gross margins.
*** difference to var. I at p= 0,001, ** at p= 0,01, * at p= 0,05

1) 1 = no attack, 9 = maximum possible attack. 2) with insecticide
3) ears and flag leaves

year	field at (see Table 1)	variable (Table 1)	maximum of attack: diseases (1-9)1): *mildew* (flag leaf)	*Sept. nod.* (ear)	*Eyespot* (stem base)	*Take-all* (stem)	Cereal aphids (sum) p.100 e.+f.3)	grain yield dt/ha (16% H_2O)	net output (DM per ha)
1982	P	I	1,3	4,0	4,1	3,9	120	98,0	3752
		II	1,1	4,2	5,1	4,0	170	95,7	3810
		IV	1,3	5,0***	5,8**	4,8	320	86,6**	3659
1983	P	I	4,0	2,5	6,2	5,4	130	83,3	2954
		II	4,3	2,7	5,8	5,1	120	93,9	3711*
		III	4,3	3,3	5,9	4,8	1350**	78,9	3112
		IV	6,1***	4,2**	6,7	5,1	2570***	69,9**	2837
	L	I	3,7	3,1	7,1	5,2	140	88,1	3197
		II	3,9	3,2	6,6	5,0	110	85,9	3119
		III	6,6*	3,6	7,0	5,5	1750***	69,3*	2302*
	R	I	4,0	3,2	7,1	5,9	80	58,6	1801
		II	3,4	3,3	7,4	5,6	50	67,7*	2462*
		III	6,0***	3,6	7,7	6,1	4650***	44,5**	1233*
1984	P	I	1,7	3,9	3,1	3,8	30	91,8	3329
		II	1,9	3,2	3,2	3,8	50	94,7	3554
		III	1,9	3,5	3,6	3,9	40 2)	91,5 2)	3424
		IV	6,0***	5,4**	6,4**	4,2	4380***	55,3**	1233*
	L	I	1,9	3,3	3,1	4,2	110	92,9	3092
		II	2,0	3,4	2,6	4,0	90	92,0	3554
		III	2,3	4,0	3,0	4,1	1420***	80,5	2740*
	R	I	2,1	3,5	3,6	4,0	750	87,7	2688
		II	2,1	3,5	3,2	3,7	710	95,2	3096
		III	2,3	4,1	4,0	4,0	5740***	59,4**	1578*

3.4 Nitrogen, Chlormequat and the necessity of pesticide use

Table 5 summarizes the results of an experiment carried out in 1985, which varied plant protection and nitrogen seperately. The data obtained reveal, that, if 250 kg/ha N are given, the maximum input of plant protection is inevitable. At a level of 200 kg/ha N the net output proved to be higher than at 250 kg/ha N in all plant protection intensities. At a level of 150 kg/ha N the net output was highest in the highest intensity, but the difference was not significant.
At the lowest intensity of plant protection, best yields/gross margins were obtained at the lowest level of N.
At the highest level of intensity, the differences (yield/net output) between N-levels were not significant. So, from the findings presented, it can be derived, that in regions, where wheat can be grown at a level of 300 kg/ha N, this level can be reduced to 150 kg/ha N without economic losses for farmers.

Table 5: Cereal aphid attack, grain yield and net output of winter wheat ("Kanzler") grown at different intensities on small plots at Heikendorf/Kiel (FRG), 1985.

*** significant difference to Var. I at p= 0,001, ** at p= 0,01, * at p= 0,05

	kg/ha N	I herbicide, chlormequat, fungicides & insecticide	II herbicide, chlormequat & fungicides	III herbicide only
Cereal aphids per ear and flag leaf (max.)	150	7	11*	12*
	200	6	10*	11*
	250	6	10*	11*
Grain yield (dt/ha)	150	89,9	87,6	68,3**
	200	92,8	85,5	52,6**
	250	89,9	79,9*	44,4***
Net output (DM/ha)	150	3509	3448	2650*
	200	3629	3273	1757**
	250	3408	2911*	1261**

4. Discussion

The studies presented here have shown again, that it is not only necessary to regard the actual grain yield, but also the net output. Furthermore it seems necessary, that every farmer, for the conditions prevailing in his farm, should try to reduce the input of N-fertilizers, not regarding the grain yield, but the net output. Table 5 shows, that these experiments should lead to a reduction of N-fertilization. With special view to the fact, that nitrates from agriculture are spoiling the quality of subsoil waters and have detrimental effects on coastal waters etc., the reduction of the use of N-fertilizers is inevitable from the environmental point of view. It should be a good chance, if this goal could be achieved without monetary losses for the farmers or the society (when paying subsidies and/or environmental "repairing " costs).

REFERENCES

AL-NAJJAR, A., BASEDOW, TH. and SCHULZ, F.A. (1989): Die Auswirkungen abgestufter Produktionsintensitäten im Weizenanbau auf Schaderreger, Erträge und Wirtschaftlichkeit. I. Phytomedizinische Aspekte. - Z. Pflanzenkrankh. Pflanzenschutz 96, 561-584.

BASEDOW, TH., SCHULZ, F.A. and AL-NAJJAR, A. (1990): Die Auswirkungen abgestufter Produktionsintensitäten im Weizenanbau auf Schaderreger, Erträge und Wirtschaftlichkeit. II. Ökonomische Aspekte. - Z. Pflanzenkrankh. Pflanzenschutz 97 (in press).

FRITZSCHE, R. and THIELE, S. (1979): Einfluß der CCC-Behandlung von Winterweizen auf die Blattlausvermehrung. - Nachrichtenbl. Pflanzenschutz DDR 33, 39.

HANISCH, H.-CH. (1980): Untersuchungen zum Einfluß unterschiedlich hoher Stickstoffdüngung zu Weizen auf die Populationsentwicklung von Getreideblattläusen. - Z. Pflanzenkrankh. Pflanzenschutz 87, 546-556.

HANSEN, W. (1986): Die Populationsdynamik von Blattläusen an Weizen in Abhängigkeit von der Qualität des Phloemsaftes bei unterschiedlicher N-Düngung. - Thesis Göttingen, 97 pp.

HINZ, B. and DAEBELER, F. (1976): Der Einfluß der Stickstoffdüngung auf die Vermehrung der Großen Getreideblattlaus, *Macrosiphum (Sitobion) avenae* (F.) auf Winterweizen. - Wiss. Z. Wilh.-Pieck-Univ. Rostock, Math.-Nat. R. 6, 653-655.

HINZ, B., DAEBELER, F. and GIESSMANN, H.-J. (1973): Untersuchungen zum Einfluß von Chlorcholinchlorid (CCC) auf die Entwicklung und Vermehrung der Getreideblattlaus *Macrosiphum (Sitobion) avenae* (F.) an Weizen. - Arch. Phytopathol. Pflanzenschutz 9, 21-27.

INTEGRATED CONTROL OF RHOPALOSIPHUM PADI, AND THE ROLE OF EPIGEAL PREDATORS IN FINLAND

J. HELENIUS

University of Helsinki, Department of Agricultural and Forest Zoology, SF-00710 Helsinki, Finland

Summary

The monitoring of the exclusively holocyclic Rhopalosiphum padi in Finland is based on: 1) regional sampling for winter egg densities on the primary host Prunus padus, 2) suction trap catches of spring migrants and 3) sampling of shoots in fields of spring cereals. When the monitoring predicts peak population densities above the economic threshold, spraying with aphicides is recommended. The abundances of natural enemies are not taken into account in the regional monitoring. In order to include the natural enemies in the integrated control program, local populations should be monitored. The key questions in this are: what would be the important species and how to make the sampling.

Preliminary results from field experiments with oats in 1986 and 1988 are presented. Removal-trapping, pitfall-trapping and predator manipulation methods were used. In 1986 Coccinella septempunctata was able to control R. padi. In the outbreak season 1988, ingress-manipulation of epigeal predators resulted in a significant 53% reduction in peak aphid densities, in spite of heavy colonization pressure and high infestation levels of 40-120 aphids/tiller at the peak period. The importance of early season predation on R. padi is discussed. Emergence trapping of newly-emerged adults for studying recruitment rates of Bembidion spp. is suggested.

1 Introduction

In Finland, populations of Rhopalosiphum padi (L.) have reached outbreak levels at 5-10 year intervals, and nine seasons in which severe damage occurred to spring cereals have been reported since 1928. Frequently, the aphid borne barley yellow dwarf virus has contributed to the crop losses (Kurppa, 1989b). Intensive research into R. padi was started about thirty years ago, and concerned distribution and damage, biology, prediction and natural enemies. Until the 80's, the work on natural enemies concentrated on the specialist predators, parasitoids and fungal diseases, and the role of generalist (epigeal) predators remained unknown.

2 Research for developing integrated control

A survey of regional distribution and damage was made during the outbreak season of 1959, when 50 000-70 000 ha was treated with 200-250 tn of parathion and DDT sprays and dusts. The average losses were estimated to be 10%, while the efficiency of the chemical control varied from prevention of total loss to yield improvements of 10%. The low efficiency was because of the late application (Raatikainen & Tinnilä, 1961). The experience motivated studies on biology and damage effects of R. padi and the associated virus (Markkula & Myllymäki, 1963; Markkula & Laurema, 1964; Bremer, 1965). Rautapää (1968) developed an aphid-index, which is the integral of the aphid population growth curve, analogous e.g. to day-degree concept, and, in order to quantify the damage relationship, he calculated regression lines of yield components and %-loss against the index in oats.

In 1974, Rautapää presented a method to predict the peak population density of R. padi, based on sampling for arrival of the first alate colonists and subsequent sampling for average density on the seedlings. A control scheme was presented, in which the spraying decision was made, when the monitoring predicted peak densities of 25 aphids per tiller. The calculations were based on the damage relationship established in the earlier studies (Rautapää 1974, 1976, Rautapää & Uoti 1976). The prediction method was improved by introduction of winter egg counts: the mortality of the eggs on the primary host is very low, and since the overwintering in exclusively holocyclic, egg counts early in winter can be used for predicting populations of spring migrants (Leather & Lehti, 1981; Leather, 1983). The present monitoring system combines winter egg counts, suction trap samples, and incidence counts on seedlings (Kurppa, 1989a).

Together with the studies aimed at designing a system and establishment of thresholds for chemical control, alternative methods for aphid control have been looked for. Screening of cereal varieties for aphid resistance did not show much promise (Markkula & Roukka 1972). The preference of R. padi towards cereals was demonstrated, and at the same time, its relative polyphagy as compared to the other two members in the guild of grass-feeding aphids, namely Sitobion aveane (Fabr.) and Metopolophium dirhodum (Rautapää, 1970).

Among the specific predators, the dominatig groups are coccinellids, especially Coccinella septempunctata L. and syrphid larvae. Aphidiids or Aphelinids frequently parasitize cereal aphids, and entomophthoraceous fungi are common (Rautapää, 1972; Clayhills & Markkula, 1974; Leather & Lehti, 1982; Rautapää, 1976; Papierok & Havukkala, 1986). The abundance of the specific predators and the rates of parasitism by parasitoids or fungal diseases are generally synchronized to the within-season development of R. padi (Rautapää, 1976; Leather and Lehti, 1982; Helenius, 1990a).

3 Role of epigeal generalist predators

The major groups of epigeal generalist predators of R. padi are ground beetles (Carabidae), rove beetles (Staphylinidae), and spiders (Araneae). The species lists from pitfall-studies closely resemble those reported in the other countries in Northern Europe, with some exceptions; e.g. Agonum dorsale (Pont.) is rare in Finnish agricultural fields (Raatikainen & Huhta, 1968; Varis et al., 1984; Niemelä et al., 1987; Helenius, in preparation).

Experiments where predator densities were manipulated by barriers and ingress/egress trenches showed that the epigeal predators can reduce aphid infestation to the extent that yield is improved. Bembidion spp. (Carabidae) were indicated as the most important group, because of the highest activity-density during the colonization and establishment phase of R. padi (Helenius, 1990b). Some preliminary results to supplement the earlier data are presented. The experiments were conducted at the Experimental Farm of the University of Helsinki (61°12' N).

3.1 Material and methods

The 1986 experiment consisted of 9 m^2 plots of spring oats, replicated six times. Removal trapping for predators was started on the 29th of May at the 1-2 leaf stage (GS 11-12), on the same date the first alate colonists of R. padi were observed. The method used has been described by Sunderland et al. (1987), except that vacuum netting was not made because of the soil was too loose, and there was only one pitfall trap of 80 mm in diameter inside the isolator, 10 cm from the wall in a shallow pit mimicking the strategy of ant lion. The 30 cm high isolators, 57 cm in diameter, were made from former paint drums and were driven 20 cm deep into the soil. Isolators were kept for 28 days, starting with three in every second plot and then adding three more after 14 days in the other plots. The six isolators were then operated so that each of the four overlapping trapping periods was replicated in three of the plots. One pitfall trap was placed in the middle of each plot. Thus, altogether 12 circles of 0.25 m^2 was sampled, the total area covered being 3.0 m^2. Pitfalls were emptied once every 3-4 days. Population densities of R. padi were monitored by sampling tillers.

The 1988 experiment aimed at estimating the effect of predator exclusion on the yield of oats in monocrops and in mixed stands with faba bean. The aspect of mixed cropping and plant competition will not be treated here. Plots of 3m x 6m were used, and the treatments were arranged in sub-plots of 1.25m x 2m. These were srаying with aphicide (dimethoate), ingress-only trench, control, and egress-only trench (for the method in arranging the manipulations, see Helenius, 1990b). There were four replications. The aphid densities were estimated by inspecting tillers in situ. The effect of trenches was not controlled by pitfall trapping of predators as in the earlier experiments in which these always operated well (Helenius, 1990b). Grain yields of oats were determined.

3.2 Results

The removal trapping by isolators yielded very few carabids of predatory importance. The burrowing species Clivina fossor was the most abundant carabid in the catch: the average catch from the isolators was 0.8/trap-day, while the catch from the control pitfalls was 0.9/trap-day. There was a peak in late July in isolators as well as in control pitfalls. The ground search yielded altogether 11 C. fossor. Trechus secalis ranked as the second largest catch from the isolators. All the other carabids were very few in the removal traps, and none was found by ground searching (Table 1).

C. septempuctata was exceptionally abundant early in the season. The peak coccinellid activity was during the 26th of June until 3rd of July, when the catch of larvae was 26.6±3.0(S.E.)/pitfall-day in the control pitfalls. The ground search on the 26th of June gave an estimated density of 100.0 larvae/m^2. The abundance of coccinellid larvae in the isolators during the second period was because of the difficulties in preventing the very numerous small larvae from entering the trap when removing the sealing net while emptying the pitfall (Table 1).

The development of the population of R. padi indicated an outbreak, but on the 25th of June a sudden decline at GS 43 (boots just visibly swollen) was observed:

	11/6	16/6	18/6	23/6	25/6	30/6
R. padi mean no. per tiller	0.6	3.5	4.1	6.3	3.0	0.3

The decline was not associated with the normal symptoms of a degenerating population such as the abundance of overcast skins, infected or parasitized aphids or dvelopment of alate morphs. Numbers of syrphid larvae were also negligible. The aphid populations did not recover in the experiment nor in the surrounding cereal fields.

In 1988, there was a mass invasion of long distance migrants of R. padi to cereal fields at GS 10-12 (one to two leaves), resulting in an extreme colonization rate of 30% of seedlings infested in the experiment. After a week, the exceptionally large native migrant populations moved to grasses, contributing to the extended colonization period of two weeks (see also Kurppa, 1989b). The populations reached peak densities 2-3 weeks earlier than normally in mid-June, at GS 4-5 (late booting, early panicle emergence). Measured by DD-accumulation, the early season was very warm which explains the rapid development of the cereals.

The resulting peak densities of aphids in the experiment were all above the economic damage threshold of 20-25/tiller. In the sprayed plots there still were aphid colonies in spite of three applications of dimethoate. The ingress-only treatment reduced the peak densities by 53% (LSD-test for ln-transformed values, $p<0.05$) in comparison to open controls. The average increase of 27% achieved by the predator exclusion treatment was not significant (F-test, df=2,12). The aphicide treatment resulted in a 75% increase in oats yield when compared to the control (LSD=950 kg/ha, $p<0.01$). In the ingress-only treatment the average yield was 33% higher than in the control, but the difference was not significant (F-test, df=3,18) (Table 2).

Table 1. Catches of most abundant species of Carabidae and <u>Coccinella septempunctata</u> from pitfall-traps, and catches from ground search. (There were 84 trap-days/period and 0.75 m^2 was searched per period.)

Period	29/5-26/6	12/6-10/7	26/6-24/7	10/7-7/8
A. Control pitfalls (number/trap-day)				
<u>Bembidion</u> spp., all	0.2	0.1	0.2	0.2
- <u>B. guttula</u> (Fabr.)	0.1	0.0	0.1	0.1
<u>Clivina fossor</u> (L.)	1.1	0.3	0.7	1.4
<u>Harpalus rufipes</u> (Deg.)	0.3	0.3	0.4	0.4
<u>Pterostichus melanarius</u> (Ill.)	0.2	0.3	0.9	1.1
<u>Trechus secalis</u> (Payk.)	0.2	0.3	0.7	0.8
<u>C. septempunctata</u> L., ad.	0.8	0.6	1.3	1.1
Coccinellidae, larvae	1.1	6.1	8.1	0.0
B. Pitfalls inside the isolators [no./trap-day (no./m^2)]				
<u>B. guttula</u>	-	0.0 (1)	-	-
<u>C. fossor</u>	0.4 (51)	0.5 (53)	0.4 (51)	1.8(196)
<u>P. melanarius</u>	0.0 (1)	-	0.0 (1)	-
<u>T. secalis</u>	0.0 (5)	0.0 (3)	0.0 (1)	0.0 (7)
<u>C. septempunctata</u>, ad.	-	-	0.0 (1)	-
Coccinellidae, larvae	0.0 (7)	0.6 (64)	0.2 (21)	-
C. Ground search (no./m^2)				
<u>C. fossor</u>	12.0	1.3	-	1.3
<u>C. septempunctata</u>, ad.	-	1.3	-	17.3
Coccinellidae, larvae	-	-	100.0	5.3

Table 2. Peak population density of <u>R. padi</u> and grain yield of oats in 1988 predator manipulation experiment. (Standard errors are given in brackets. Means within column followed by same letter are not significantly different.)

	<u>R. padi</u> number/tiller		Oats yield kg/ha	
Egress-only	114.6 (10.3)	a	3 063.9 (576.2)	a
Control	90.3 (14.3)	a	2 695.4 (341.3)	a
Ingress-only	41.8 (9.9)	b	3 589.0 (476.1)	a
Aphicide	(some colonies)		4 745.4 (493.6)	b

4 Discussion

The experience in 1986 showed how C. septempunctata alone can control R. padi, provided that the abundance and activity are high enough during the establishment phase of the prey population. At the moment, there is no method to predict abundance of coccinellids. The weather plays an important role in determining the activity of coccinellids during the critical colonization and establishment phases of R. padi. Predation by coccinellids is facilitated by warm and dry weather. In these circumstances, action threshold of aphicide spraying could be raised.

Relative to the pitfall catches, the catches of carabids in the removal traps were low. The number of traps used was clearly too small for accurate estimation of absolute population densities of carabids. Another problem was that operating the traps for four weeks may have allowed newly-emerged adults to be caught.

The 1988 experiment indicated that epigeal predation can significantly reduce peak aphid densities also in years of heavy colonization. This may have been facilitated in the season 1988 by the very early arrival of the colonists, which became exposed to predation by Bembidion spp. when these were most numerous and abundant. However, the aphid populations exceeded the economic damage threshold also in plots where predation was enhanced by ingress-only treatment, and no yield improvement was achieved, contrary to the results at moderate infestation levels (Helenius, 1990b).

BYDV-infestation was an important component of the aphid damage during the season (Kurppa, 1989b, Kurppa et al., 1989). In order to prevent the spread of the virus the aphid populations should be controlled early. This requirement creates problems in relying on natural enemies: a monitoring scheme should reliably predict the impact of predation before the aphicide should be sprayed, within two weeks from the arrival of the first colonists.

The present prediction system (Kurppa, 1989a) is reliable and, according to a similar survey as performed in 1959, it resulted in a much better protection of the crops during the outbreak of 1988 than was the case during the outbreak of 1959 (Kurppa, 1989b). However, the scheme relies entirely on the use of aphicides: the next challenge would be to include the coccinellids and general epigeal predators into the integrated control of R. padi.

Cultural methods should be developed that enhance the epigeal predators early in the season. When comparing different cultural practices it would be important not only to estimate population densities or mortality rates of the overwintered adults, but also to obtain data on their reproductive success. For this purpose, emergence traps could be used (Fig.). A preliminary result of emergence trapping for recruitment rate of Bembidion spp. in a spring barley field was 15-20 newly-emerged specimens per square meter, the development time being ca. 400 day-degrees (>5°C) (Helenius, Holopainen and Tolonen, in preparation).

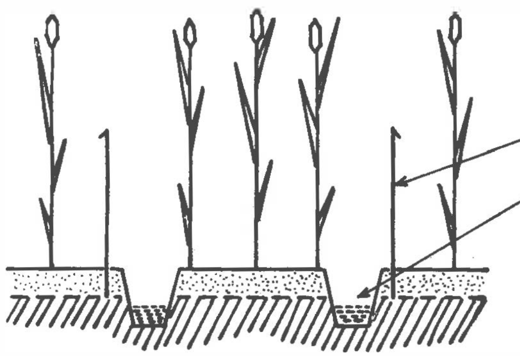


Figure. Illustration of an emergence trap for trapping newly-emerged carabids in a cereal field. For winged species a sealing net would be required. The trap may not be suitable for burrowing species.

Acknowledgements

I wish to thank the members of the Nordic Research Group for collaboration, and Mr Robert Harper for linguistic revision of the manuscript. The study was funded by the National Research Council for Agriculture and Forestry.

References

1. BREMER, K. (1965). Characteristics of the barley yellow dwarf virus in Finland. Ann. Agric. Fenn. 4: 105-120.
2. CLAYHILLS, T. and MARKKULA, M. (1974). The abundance of coccinellids on cultivated plants. Ann. Ent. Fenn. 40: 49-55.
3. HELENIUS, J. (1990a). Incidence of specialist natural enemies of Rhopalosiphum padi (L.) (Hom., Aphididae) on oats in monocrops and mixed intercrops with faba bean. J. Appl. Ent. 109: 136-143.
4. HELENIUS, J. (1990b). Effect of epigeal predators on infestation by the aphid Rhopalosiphum padi and on grain yield of oats in monocrops and mixed intercrops. Ent. Exp. et Appl. In press.
5. KURPPA, A., KURPPA, S. and HASSI, A. (1989). Importance of perennial grasses, and winter cereals as hosts of barley yellow dwarf virus (BYDV) related to fluctuations of vector aphid population. Ann. Agric. Fenn. 28: 309-315.
6. KURPPA, S. (1989a). Predicting outbreaks of Rhopalosiphum padi in Finland. Ann. Agric. Fenn. 28: 333-347.
7. KURPPA, S. (1989b). Damage and control of Rhopalosiphum padi in Finland during the outbreak of 1988. Ann. Agric. Fenn. 28: 349-370.

8. LEATHER, S.R. (1983). Forecasting aphid outbreaks using winter egg counts: An assessment of its feasibility and an example of its application in Finland. Z. ang. Ent. 96: 282-287.
9. LEATHER, S.R. and LEHTI, J.P. (1981). Abundance and survival of eggs of the bird cherry-oat aphid, Rhopalosiphum padi in southern Finland. Ann. Agric. Fenn. 47: 125-130.
10. LEATHER, S.R. and LEHTI, J.P. (1982). Field studies on the factors affecting the population dynamics of the bird cherry-oat aphid, Rhopalosiphum padi (L.) in Finland. Ann. Agric. Fenn. 21: 20-31.
11. MARKKULA, M. and LAUREMA, S. (1964). Changes in the concentration of free amino acids in plants induced by virus diseases and the reproduction of aphids. Ann. Agric. Fenn. 3: 265-271.
12. MARKKULA, M. and MYLLYMÄKI, S. (1963). Biological studies on cereal aphids, Rhopalosiphum padi (L.), Macrosiphum avenae (F.), and Acyrthosiphum dirhodum (Wlk) (Hom., Aphididae). Ann. Agric. Fenn. 2: 33-43.
13. MARKKULA. M. and ROUKKA, K. (1972). Resistance of cereals to the aphids Rhopalosiphum padi (L.) and Macrosiphum avenae (F.) and fecundity of these aphids on Graminae, Cyperaceae and Juncaceae. Ann. Agric. Fenn. 11: 417-423.
14. NIEMELÄ, J., HAILA, Y. and HALME, E. (1987). Carabid assemblages in southern Finland, a forest-field comparison. Acta Phytopath. Ent. Hung. 22: 417-424.
15. PAPIEROK, B. and HAVUKKALA, I. (1986). Entomophthoraceous fungi parasitizing cereal aphids in Finland. Ann. Ent. Fenn. 52: 36-38.
16. RAATIKAINEN, M. and HUHTA, V. (1968). On the spider fauna of Finnish oat fields. Ann. Zool. Fenn. 5: 254-261.
17. RAATIKAINEN, M. and TINNILÄ, A. (1961). Occurrence and control of aphids causing damage to cereals in Finland in 1959. Publ. Finn. State Agric. Res. Board 183. 27 p.
18. RAUTAPÄÄ, J. (1968). Changes in the yield and protein quantity of oat caused by Rhopalosiphum padi (L.) (Hom., Aphididae). Ann. Agric. Fenn. 7: 95-104.
19. RAUTAPÄÄ, J. (1970). Preference of cereal aphids for various cereal varieties and species of Graminae, Juncaceae, and Cyperaceae. Ann. Agric. Fenn. 9: 267-277.
20. RAUTAPÄÄ, J. (1972). The importance of Coccinella septempunctata L. (Col., Coccinellidae) in controlling cereal aphids and the effect of aphids on the yield and quality of barley. Ann. Agric. Fenn. 11: 424-436.
21. RAUTAPÄÄ, J. (1974). Viljan kirvat - torjunta ja runsauden ennustaminen. Kasvinsuojelulehti 7: 35-42.
22. RAUTAPÄÄ, J. (1976). Population dynamics of cereal aphids and method of predicting population trends. Ann. Agric. Fenn. 15: 272-293.
23. RAUTAPÄÄ, J. and UOTI, J. (1976). Control of Rhopalosiphum padi (L.) (Hom., Aphididae) on cereals. Ann. Agric. Fenn. 15: 101-110.
24. SUNDERLAND, K.D., HAWKES, C., STEVENSON, J.H., McBRIDE, T., SMART, L.E., SOPP, P.I., POWELL, W., CHAMBERS, R.J. and CARTER, O.C.R. (1987). Accurate estimation oof invertebrate density in cereals. Bull. SROP/WPRS Bull. 1987/X/1: 71-81.
25. VARIS, A.-L., HOLOPAINEN, J.K. and KOPONEN, M. (1984). Abundance and seasonal occurrence of adult Carabidae (Coleoptera) in cabbage, sugar beet and timothy fields in southern Finland. Z. ang. Ent. 98: 62-73.

Effects of some insecticides on aphids and beneficial arthropods in winter wheat

U. Heimbach
Biologische Bundesanstalt für Land- und Forstwirtschaft,
Institut für Pflanzenschutz in Ackerbau und Grünland

Summary

The results of fieldtrials with some aphicides in winter wheat are presented. In 1988 pirimicarb turned out to be the most effective aphicide; fenvalerate and parathion had similar effects and endosulfan was less effective. In 1989 lambda-cyhalothrin and again pirimicarb were very effective. The effectiveness of the three other insecticides was comparable to that of 1988.
Apart from effects on aphids the mortality of beneficial arthropods was observed. The number of dead insects counted after the application was nearly the same in the untreated or pirimicarb treated plots. But more dead insects were found in the fenvalerate, endosulfan and even more in the parathion treated plots. In 1989 in the lambda-cyhalothrin treated plot were about 10 times as much dead insects as in the parathion plot.
The number of spiders caught with pit fall traps and ground photo-eclectors was reduced in the endosulfan, fenvalerate and especially in the lambda-cyhalothrin treated plots.
Altogether pirimicarb turned out to be very effective on aphids but ineffective on beneficials. Lambda-cyhalothrin had the most marked effects on aphids and beneficial arthropods.

1.1 Introduction

The aim of the IOBC working groups "Integrated control in cereal crops" and "Pesticides and beneficial organisms" is to reduce the number of applications and the amount of pesticides used and to find out selective pesticides. Therefore a trial programme was started with some aphicides in winter wheat in West Germany in that we looked for both, effectiveness on the aphids and on some beneficial arthropods.

1.2 Material and Methods

Field experiments

Field studies were performed in 1988 and 1989 near Braunschweig in winter wheat (plot size: 1 ha) conventionally treated with fertilizers and pesticides. The aphicides (table 1.) were sprayed with a common field spraying machine (300 l water per ha). To count the aphids 50 ears and 50 flag leafs per plot were cut off and all insect were extracted by a simplified Kempson-extractor (KEMPSON et al. 1963).

Table 1.: Aphicides used in the trials

common name	active ingredient		application rate
Pirimor-Granulat	pirimicarb	50 %	100 g a.i/ha
Sumicidin 10	fenvalerate	100 g/l	30 g a.i/ha
Thiodan 35 flüssig	endosulfan	355 g/l	213 g a.i/ha
E 605 forte	parathion	500 g/l	105 g a.i/ha
Karate	lambda-cyhalothrin	50 g/l	10 g a.i/ha

For several days after the application we searched for dead insects in the tram lines in the centre of the plots. Additionally 10 pit fall traps per plot (1989 only 5) were dug and left open about one week before and after the application. In the centre of the plots 4 ground photo-eclectors (0,25 m2 each) were placed. These eclectors were taken to new places about every week.

Laboratory experiments

Laboratory reared Poecilus cupreus (Coleoptera, Carabidae) (HEIMBACH 1989) that were ready to lay eggs, were sprayed (5 beetles in 5 replicates per treatment) in boxes of about 170 cm2 surface area containing wet sandy soil (HEIMBACH 1988). Food and water was added twice a week in a climatic chamber (20° C, 80 % humidity, longday of 16 hours). The mortality, the egg production, the hatching from the eggs and the development of the larvae were recorded.

1.3 Results and Discussion

Insect pests

In 1988, due to the weather conditions, the application was carried out quite late (4 July 88, GS 75). 3 days before the application the number of aphids (fig. 1.) ranged between 8 and more than 20 aphids per ear and flag leaf in the different plots. The efficacy of pirimicarb was very high along with quick killing of the aphids. Parathion and fenvalerate were a little bit less effective and endosulfan even less. But already some days after the application the population density in the untreated plot decreased. In 1989 the application was at GS 61-65 (12 June 89). At that time about 8 aphids were found per ear and flag leaf (fig. 2.). Pirimicarb and lambda-cyhalothrin were very effective. The effectiveness of the other three insecticides was quite comparable to that of 1988. But in 1989 the population density of the aphids increased some days after the application. In both years about 90 % of the aphids were Sitobion avenae. The number of thysanopteres (about 8 per ear and flag leaf were extracted in 1989) was reduced slightly in both years by the applicaton of parathion. In 1989 lambda-cyhalothrin reduced them by about 75 %. The other insecticides did not effect the thysanopteres. But it has to be mentioned, that the extraction-method gave less than 100 % of the number of thysanopteres.

Beneficial arthropods

In 1988 we collected dead insects on successive days in the tram lines (table 2.). Parathion killed most of the collected beneficial arthropods. Even 3 days after the application we found some dead ones. In 1989 (table 3.) the

Table 2.: Collecting of dead animals in tram lines (600/400 m) after the application

treatment 04-07-1988

		number of dead predatory Coleoptera and Araneae				number of dead Diptera and Hymenoptera			
a.i / ha		5-07	6-07	7-07	total	5-07	6-07	7-07	total
untreated	-	3	0	0	3	0	0	0	0
pirimicarb	100 g	11	0	1	12	25	4	2	31
fenvalerate	30 g	11	0	0	11	8	2	0	10
endosulfan	213 g	30	8	0	38	42	11	0	53
parathion	105 g	63	6	15	84	62	8	14	84

number of dead insects counted after the application was nearly the same in the untreated and the pirimicarb treated plots. But as in 1988 more dead insects were found in the fenvalerate, endosulfan or parathion treated plots. In 1989 in the lambda-cyhalothrin treated plot were about 10 times as many dead insects as in the parathion treated plot. Even 10 days after the application beneficials were still dying

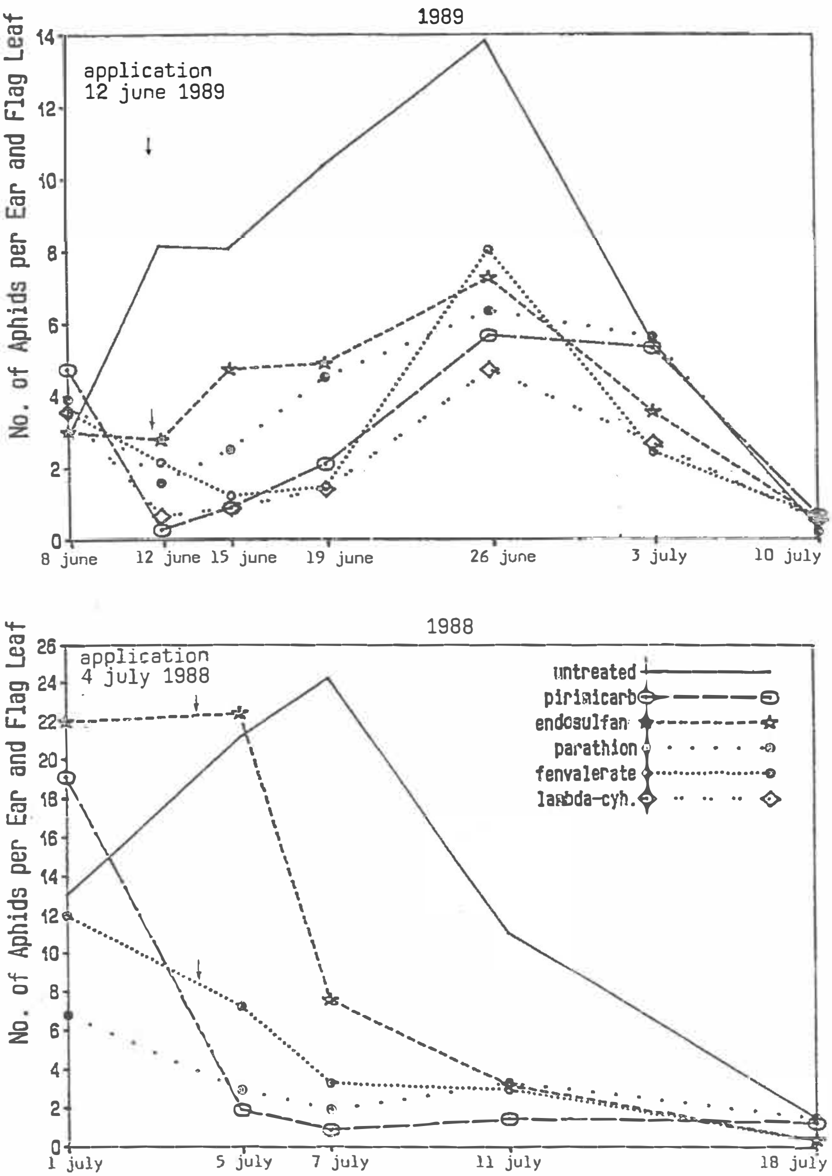


fig. 1. Number of aphids per ear and flag leaf at different dates before and after the application of insecticides in wheat

in this plot, whereas at the same time the population density of aphids already increased. In 1988 40 % of the collected dead predators were carabids and 45 % staphylinids. In 1989 10 % were carabids, 20 % coccinellids and 63 % staphylinids, most of them Tachyporus spec.

Due to the cannibalism of other predators like carabids, mice and birds only an unknown percentage of the arthropods hit by an application will be found. Also many small predators and soft-skinned arthropods like spiders cannot be found if they are hit by a pesticide. Sampling of dead insects is a quite rough method, but at least the effects of different treatments can be evaluated if the plot size is sufficient and the density of the predators in the plots is comparable.

Table 3.: Collecting of dead animals in tram lines (400 m) after the application

treatment 12-06-1989

number of dead predatory Coleoptera and Araneae found

a.i / ha		13-06	14-06	15-06	19-06	20-06	22-06	total
untreated	-	0	2	0	0	0	1	3
pirimicarb	100 g	2	0	2	0	-	-	4
fenvalerate	30 g	8	10	9	0	-	-	27
endosulfan	213 g	-	5	3	2	-	-	(10)
parathion	105 g	17	2	11	1	0	-	31
lambda-cyhalothrin	10 g	97	70	92	14	15	12	300

number of dead Diptera and Hymenoptera found

a.i / ha		13-06	14-06	15-06	19-06	20-06	22-06	total
untreated	-	0	0	0	0	0	1	1
pirimicarb	100 g	1	0	0	0	-	-	1
fenvalerate	30 g	5	5	0	0	-	-	10
endosulfan	213 g	-	2	0	0	-	-	(2)
parathion	105 g	1	0	1	1	0	-	3
lambda-cyhalothrin	10 g	29	28	23	0	4	6	90

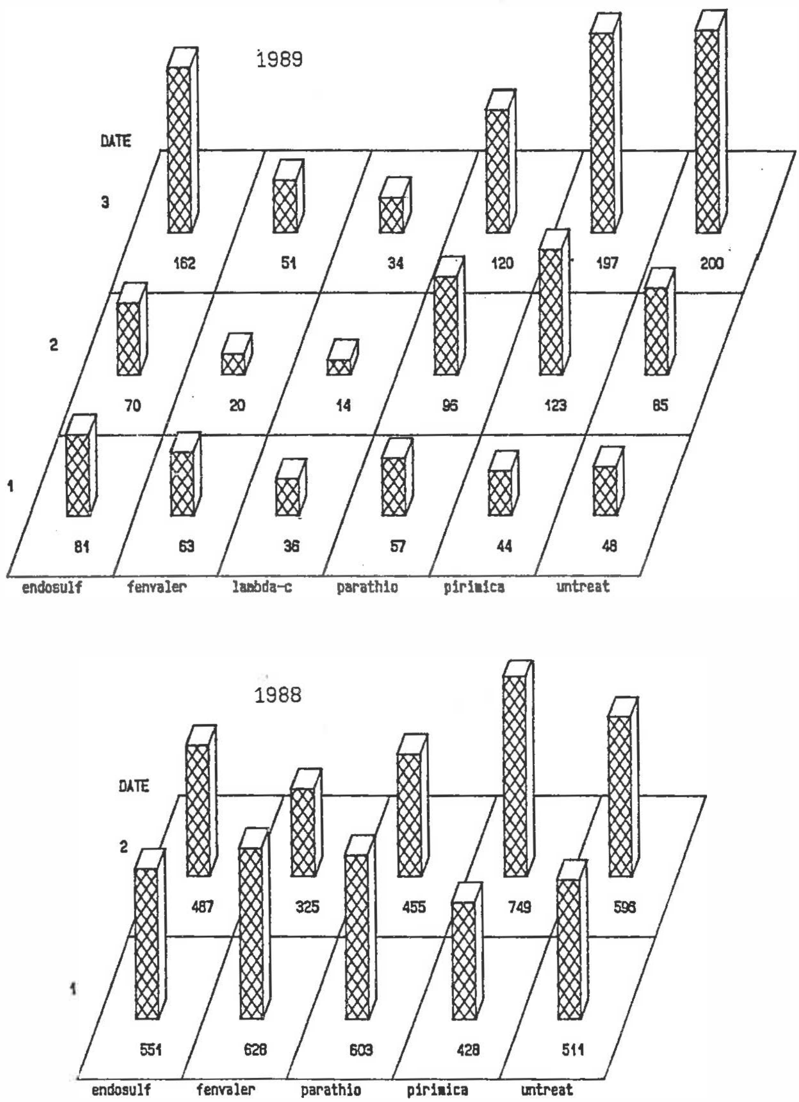


fig. 2. Number of spiders caught with pit fall traps (10 per plot 1988, 5 per plot 1989) at different dates (1988: 1 = 29 june - 4 july, 2 = 6 - 11 july; 1989: 1 = 9 - 12 june, 2 = 13 - 19 june, 3 = 19 - 26 june)

The results of the laboratory test (table 4.) show, though laboratory tests like this are a kind of worst case test, that only parathion had effects on the mortality of Poecilus cupreus. Endosulfan, fenvalerate and pirimicarb had not even effects on the reproductivity of this carabid beetle. The influence of parathion on the reproductivity is caused by the lack of males after the application.

Table 4.: Mortality and reproduction of Poecilus cupreus in a laboratory test
treatment 4-07-1988, (5 replicates, 5 beetles each)

a.i / ha		% mortality of adults 29-08	24-11	number of eggs	time of develop. larva - adult	hatched beetles per 100 eggs
untreated	-	4	4	1183	42,5 days	39
pirimicarb	100 g	4	16	1445	45,3 "	35
fenvalerate	30 g	4	4	1961	44,7 "	40
endosulfan	213 g	4	32	1582	42,8 "	49
parathion	105 g	84	84	41	-	0

The number of Araneae (fig. 2.) caught in pit fall traps after the application was influenced particularly by lambda-cyhalothrin and fenvalerate treatment (fig. 3.). But also parathion and endosulfan seem to have negative effects. The activity of spiders on the soil surface was enhanced by the pirimicarb application which might be due to the high numbers of dying aphids on the soil surface and the lack of aphids as prey within the crop. But the amount of insects caught in pit fall traps is influenced by many factors so that the results are difficult to interpret and often not sufficient (BASEDOW et al. 1987). In 1989 there were not enough carabids and other predators except spiders in the pit fall traps to allow any interpretation. In 1988 changing weather conditions before and after the application led to very different numbers of predators even in the untreated plot; to give an example: 3,9 Pterostichus spec. per day and trap to only 1,1 after the application.

Ground photo-eclectors catch all insects within the eclector, that are attracted by light. Fig. 4. gives the number of Araneae caught by eclectors. Fenvalerat and lambda-cyhalothrin show distinct effects on spiders. But a more thorough examination of the effects of parathion and especially endosulfan on spiders ought to be done. The evaluation of the trial programme is not yet completed. There were quite a lot of Staphylinidae in the photo-eclectors that may indicate some additionally effects.

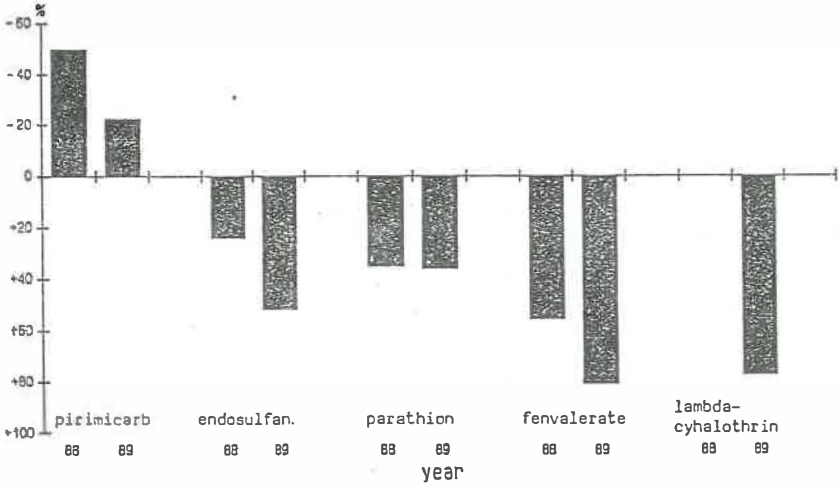


fig. 3. Effectiveness (HENDERSON & TILTON 1955) of some insecticides on spiders caught with pit fall traps (1988: 29 june - 4 july and 6 - 11 july, appl. 4 july; 1989: 9 - 16 june and 13 - 26 june, appl. 12 june)

Altogether pirimicarb, with an application rate that was reduced from 150 g a.i/ha (officially recommended rate in West Germany) to 100 g a.i/ha, turned out to be very effective on aphids but ineffective on beneficials. Lambda-cyhalothrin had the most marked effects on aphids and beneficial arthropods. The results of the trials show that from the entomological point of view pirimicarb should be used in integrated pest management in winter wheat.

References

Basedow, T., Beckmann, C., and Runge, I. (1987). Problematik von Freilandversuchen zur Prüfung der Wirkung von Pflanzenschutzmitteln auf epigäische Raubarthropoden im Ackerbau. Z. Pflanzenkh.Pflschutz. 94, 260-275

HEIMBACH, U. (1988). Nebenwirkungen einiger Fungizide auf Insekten. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes 40 (12), 180-183

HEIMBACH, U. (1989). Massenzucht von Poecilus cupreus (Col., Carabidae). Verhandlungen der Gesellschaft für Ökologie Osnabrück 1989, Bd. XIX/I, 228-229

Henderson, C.F. and Tilton, E.W. (1955). Test with acaricides against the brown wheat mite. Journal of Econ. Entomol. 48, 157-161

Kempson, D., Lloyd, M. and Ghelardi, R. (1963). A new extractor for woodland litter. Pedobiologia 3, 1-21

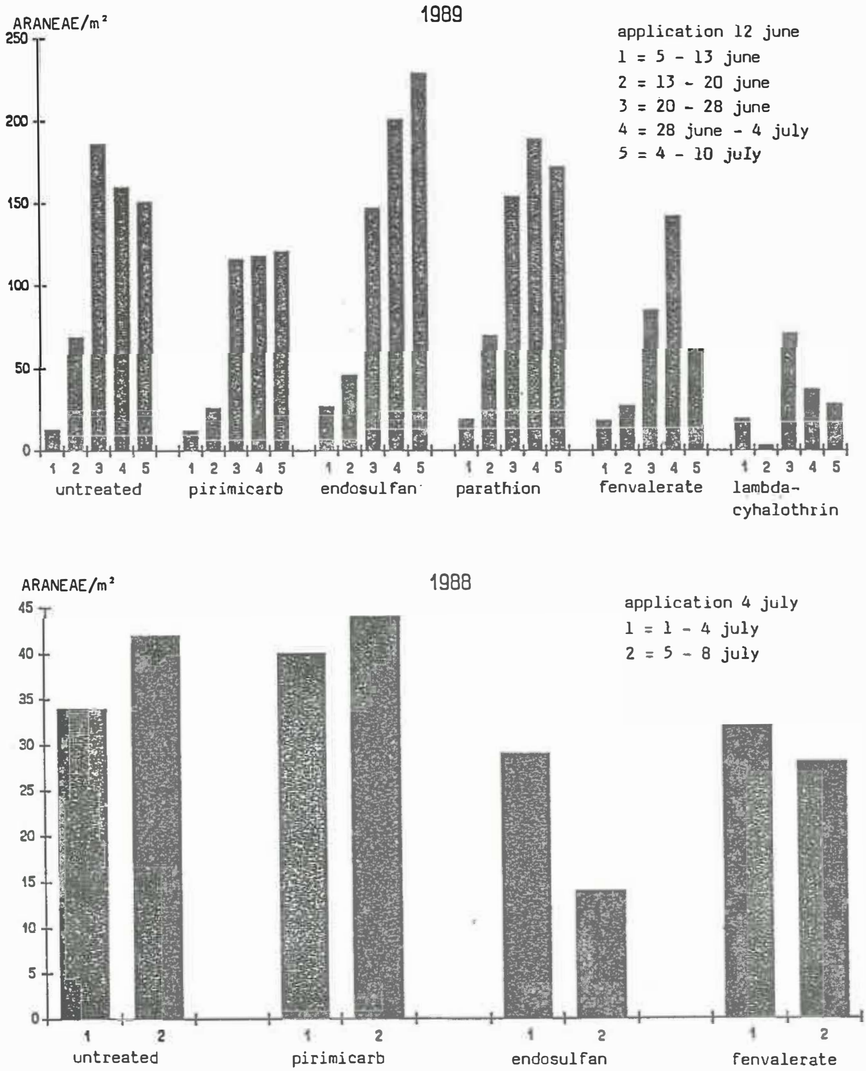


fig. 4. Number of spiders caught with ground photo-eclectors (1m²) at different dates

ACTIVITY AND POPULATION DENSITY OF EPIGEAL ARTHROPODS IN FIELDS OF WINTER WHEAT

M. LÜBKE (*)

(*) Martin-Luther-Universität Halle-Wittenberg,
Sektion Pflanzenproduktion,
Lehrstuhl Phytopathologie und Pflanzenschutz,
Ludwig-Wucherer-Straße 2, 4020 Halle (S). F.R.G.

SUMMARY

Experiments for estimating activity density of epigeal arthropods were carried out from April to August of the years 1986 to 1989 near Halle/S. (FRG) with pitfall traps. Alltogether 8 formalinfilled pitfall traps let into the soil so that 4 traps were standing in 25 m and 100 m distance from field edge. Pitfall traps were emptied weekly. Experiments should give results about proportions of epigeal arthropods, their activity density and dominance structure.

RESULTS

* Activity density

Spiders (Araneae), ground beetles (Carabidae) and staphylinid beetles (Staphylinidae) mostly characterized as carnivorous although within this taxa are phytophagous (Carabidae) and saprophagous or omnivorous (Staphylinidae) living species. This fact was not considered. Proportion of spiders amounts to 53 to 58 per cent, those of ground beetles 10 to 17 per cent in the years 1986 to 1989 (Table 1). The proportion of Staphylinid beetles was between 29 and 35 per cent. There were no essential differences between the separate years.

Activity density of spiders always reached its maximum mid to end July. The highest activity density was registered in 1988 with 20 individuals per day and trap. Most of spiders belong to the Linyphiidae, especially Erigoninae and Linyphiinae. Staphylinid beetles catches reached a maximum of 5 individuals per day and trap. There were no large differences between the separate years. Catches in spring were higher as in the summer months. The high numbers of staphylinids in spring were due to the msot frequent species *Tachyporus hypnorum* (L.). The most interesting group of epigeal arthropods are the ground beetles. The maximum catch was 3 individuals per day and trap. The activity density in the separate years was relatively constant. Most beetles were catched when the weather was wet and warm. Furthermore the dominance of the different species in wheat fields was examined. *Poecilus cupreus* (L.) always renders as eudominant species. *Platynus dorsalis* (Pont.), also was an eudominant species, with exception of 1987. Further eudominant and dominant species were *Bembidion lampros* (Herbst), *Bembidion quadrimaculatum* (L.) and *Pterostichus melanarius* (Ill.).

Diversity index (H_S) and eveness (E) of the ground beetle communities were calculated (table 2). Diversity of ground beetles in 1988 was the highest. The eveness refers to regular share of the species. In 1988, 5 species reached a proportion of over 10 per cent of the whole catch. However differences of diversity and eveness between the separate years were low. Moreover a comparison of the catches was carried out regarding species identity (Jaccard's index) and dominance identity (Renkonen's coefficient) between the separate wheat fields (table 3). Mostly there were between the years 22, between 1986 and 1989, 24 common species and only 11 not common species. The Jaccard's index showed this fact. The relative frequencies of the species corresponding to 84 per cent between 1986 and 1987. Similarity of catches in 1988 and 1989 only corresponding to 56 per cent. In relation to 1988 all years showed not so high correspondence. As reason come into question the species *Poecilus cupreus* (L.) which amounted to an activity dominance of 32 per cent in 1986, 36 per cent in 1987, 38 per cent in 1989 and only 11 per cent in 1988. This species also has had a low activity density in 1988.

*** Population density**

Investigations of population density of epigeal arthropods were first of all applied to registration of ground beetles. In this purpose square-meter-method, capture-recapture-method and wet extraction were used. These methods should be compared with regard to assertion about population density of ground beetles. As fare as it was possible by use of this methods to catch spiders and staphylinid beetles, an estimation of population density was done. Above methods require relative much time for accomplishment. Therefore mostly only a low number of repetitions were possible.

Table 1 : Proportions (in per cent) of epigeal arthropods in winter wheat.

	1986	1987	1988	1989
Araneae	58	53	53	56
Carabidae	13	17	12	10
Staphylinidae	29	30	35	34

Table 2 : Diversity index (H_S) and Eveness (E) of ground beetle communities in winter wheat

	1986	1987	1988	1989
Species quantity	29	28	32	30
Diversity	2,28	2,20	2,46	2,18
Eveness	0,68	0,66	0,71	0,64

Table 3 : Species identify (Jaccard's index cj) and dominance identify (Renkonen's coefficient : ID) of ground beetle communities in winter wheat.

	1987 cj/ID	1988 cj/ID	1989 cj/ID
1986	1,69/83,51	1,29/67,12	2,18/76,87
1987	-	1,64/66,26	1,57/70,62
1988	-	-	1,22/55,90

Square-meter-method

Experiments were carried out in the years 1987 and 1988 at 25 m and 100 m distance from field edge. Quadrats of one meter side lenght consisted of plastic material pressed into soil. Hang over plants were cut to prevent an escape of animals. Each quadrat preserved three formalinfilled pitfall traps. Pitfall traps were emptied first time 48 hours after the beginning of the experiment, then weekly after sinking into soil. Catches of different ground beetles and of the three groups of epigeal arthropods are represented in table 4. There are discernible tendencies to results of activity density. A comparision of activity and population density of the most important ground beetle *Poecilus cupreus* (L.) was carried out. At May and June of 1987 three individuals par m^2 were established. Activity density at this time was also high. The low catches with pitfall traps in 1988 face adequate population densities.

Capture-recapture-method

Plots of 4 m^2 size were established from plastic material. Four dry pitfall traps were sinked in this plots. Traps were emptied at intervals of a few days. Catched beetles were marked with nitro colour and after then left back into the plots. A population density of two individuals per m^2 of *Poecilus cupreus* (L.) was ascertained by this method. At June of 1988 the population density of this beetle was 0,5 individuals per m^2 what corresponds with results of the square-meter-method. Assertions about spiders and staphylinid beetles were not possible by this method.

Wet extraction

Investigations with wet extraction (BRENOE, 1987) carried out only at May till July in 1988. Quadrats of 1 m^2 size made of plastic material were sinked into soil. After that 120 l water were poured in the separate plots which were observed for nearly half an hour. Only small beetles especially *Trechus quadristriatus* (Schrank) were catched. By pitfall traps at this time only 0,02 individuals per day and trap were sampled. By use of this method also many staphylinid beetles especially *Tachyporus hypnorum* (L.) were catched.

Definitive methods should be estimated with regard to their practical application. Investigations for activity density are easy to carry out. There are scarcely subjective mistakes. All groups of epigeal arthropods may be catched, estimating population density is only possible by square-meter-method, partly also with wet extraction. The capture-recapture-method is suitable for population density investigation of ground beetles, but it is more expensive. The use of the methods should be choosen adequate to the aim.

Table 4 : Results of square-meter-method for estimating population density of epigeal arthropods.

	13.5.87- 26.5.87	26.5.87- 18.6.87	18.5.88- 1.6.88	1.6.88- 22.6.88	22.6.88- 1.88.88
P. cupreus	2,50	3,25	0,25	0,50	0
P. dorsalis	0,75	1,00	1,00	0,75	0
P. melanarius	0,25	0,50	0,25	0,50	0
T. 4-striatus	0	0,50	0	5,50	2,50
other species	1,00	3,00	5,75	4,25	5,00
Carabidae	4,50	8,25	7,25	11,50	7,50
Staphylinidae	83,00	51,25	59,75	131,00	114,00
Araneae	12,25	6,50	3,25	21,75	65,50

Results of experiments for activity density were used for predator-prey-relations. This is especially interesting because the active animals are catched. As well this method are applied for investigations of side effects of pesticides against beneficial arthropods. Those experiments can be completed by square-meter-method or wet extraction. Wet extraction probably renders catches of beetles with high population density and low activity density like the species *Trechus quadristriatus* (Schrank).

REFERENCE

BRENOE, J. 1987. Wet extraction - a method for estimating populations of Bembidion Iampros (Herbst) (Coleoptera, Carabidae). *J. appl. Ent. 103*, 124-127.

TRAVAUX REALISES EN FRANCE, A L'INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE, SUR LA PYRALE DU MAÏS, *Ostrinia nubilalis* Hbn. (Lep. Pyralidae)

N. HAWLITZKY
Station de Zoologie
CRA de Versailles 78026 VERSAILLES CEDEX

En France, un des ravageurs du maïs, *Ostrinia nubilalis* Hbn. (Lep. Pyralidae) est très étudié : insecte d'intérêt agronomique, il peut, par les dégâts que produisent les stades larvaires, entrainer des diminutions de rendement notables allant jusq'à 20 quintaux/ha, ce qui représente 1/4 à 1/5 des rendements obtenus.

Ce ravageur sévit, avec un nombre variable de générations selon les régions, du SUD-EST et du SUD-OUEST (2 générations), au BASSIN PARISIEN (1 à 1,5 générations) et à l'EST de la France (1 génération, ALSACE). Depuis environ 2 ans, il commence à envahir le NORD-OUEST.

Compte tenu de son importance économique, cette pyrale est l'objet d'une concentration de travaux de recherches tant fondamentaux que finalisés.

Plusieurs laboratoires de l'INRA, (en collaboration avec des unités d'Universités, du CNRS, d'Instituts techniques et des firmes privées), appartenant à des stations de recherches implantées en différentes localisations géographiques (SUD-OUEST : BORDEAUX; SUD-EST: ANTIBES; EST : COLMAR; BASSIN PARISIEN : VERSAILLES) ont choisi cet insecte comme modèle biologique et étudient les aspects suivants :

Sélection

- Sélection de variétés résistantes du maïs aux chenilles de la pyrale (Département de Zoologie : BORDEAUX : P. ANGLADE, responsable du groupe I.W.G.O. (International Working Group on *Ostrinia nubilalis*); Département d'Amélioration des plantes : MONTPELLIER : A. PANOUILLE ; F. KAAN). (1) (2)

Dynamique de population

- Dynamique de population : évolutions qualitative et quantitative (larves, chrysalides, adultes, oeufs) et facteurs abiotiques; caractérisation thermique,en sommes de degrés-jour,des évènements biologiques de la pyrale; recherche d'éléments prévisionnels et/ou indicateurs de l'apparition des stades. (Département de Zoologie : COLMAR : M. STENGEL; VERSAILLES : N. HAWLITZKY).(3)(4)

- Modélisation de la dynamique de population : élaboration de sous modèles : sous modèles de développement larvaire, de mortalité, de comportement larvaire, de dégâts et de rendement (Département de Zoologie : VERSAILLES : B. GOT; J.M. LABATTE) en fonction des dates d'infestation, des stades phénologiques et des variétés, des facteurs climatiques. Sous modèles déjà testés et validés ou en cours de construction. D'autres sous modèles du cycle de la pyrale, complémentaires des précédents,seront mis à l'étude ultérieurement.(5)(6)(7)

- Physiologie du développement et en particulier du développement de diapause et de la levée de diapause dont les données seront prises en compte dans le sous modèle de développement. (Département de Zoologie : VERSAILLES ; L. PEYPELUT, Université de BORDEAUX; L. LAVENSEAU, effet d'analogue d'hormone juvénile sur ce développement (VERSAILLES : G. GADENNE). (8)(9)(10)

Dynamique et comportement : Relations "Plante-Insecte"

- Dynamique de la ponte en fonction de la plante hôte : choix du site de ponte par contact et intensité de ponte en fonction de la nature de la plante hôte (genre, variété, hybride) du stade phénologique, du niveau foliaire et du phylloplan (composition chimique et structure de la surface des feuilles. Composition liée au caractère intrinsèque de la feuille et aux populations de bactéries phytopathogènes se développant en épiphytes.(11)(12)

- Recherche des facteurs responsables du choix. (Département de Zoologie : VERSAILLES : S. DERRIDJ; P. BARRY; BORDEAUX : P. ANGLADE; Département de Physiologie végétale : VERSAILLES : V. FIALA; J.P. BOUTIN; F. FERRON; Département de Pathologie végétale : VERSAILLES D. MARTIN; ANGERS : C. MANCEAU).(13)

- Comportement d'approche, de choix par contact de la plante hôte et d'oviposition en fonction de la plante hôte (espèce végétale, variété, hybride, stade phénologique (Département de Zoologie: VERSAILLES-ENSH VERSAILLES : P. ROBERT).

- Mise en évidence, rôle et nature de composants volatils des plantes hôtes dans le comportement de reconnaissance à distance. Cartographie des structures sensorielles et réponses électrophysiologiques à ces composants (Département de Zoologie : BURES SUR YVETTE: D. THIERRY et F. MARION POLL).(14)(15)

Dynamique de population et ennemis naturels : Relations "Insecte - Insecte".

- Dynamique de population d'insectes entomophages libérés en lâchers inondatifs et saisonniers (Trichogrammes : *Trichogramma brassicae* Bezd., Hym. Trichogrammatidae) et coïncidence spatio temporelle avec la pyrale. Elaboration d'une méthode assurant d'une part le synchronisme des premières pontes et l'émergence des oophages, d'autre part la couverture régulière et complète de la période de ponte du ravageur.

L'ensemble de ces études a conduit à l'élaboration d'une méthode de lutte biologique mise en pratique, à l'échelle commerciale, depuis 1984 et à son affinement,actuellement,pour une efficacité maximale. (Département de Zoologie : ANTIBES : J. VOEGELE; COLMAR : M. STENGEL; VERSAILLES : N. HAWLITZKY; U.N.C.A.A. : Union Nationale des Coopératives Agricoles d'Approvisionnement : B. RAYNAUD). (16)

- Caractéristiques biologiques des oophages en conditions contrôlées (J. VOEGELE), en conditions contrôlées, semi contrôlées et naturelles (N. HAWLITZKY et P. BARRY) sous l'effet des facteurs thermiques, hydriques et précipitations dont l'apport des données a contribué à l'élaboration de la méthode de lutte (J. VOEGELE; N. HAWLITZKY) à la mise au point d'un élevage de masse (J. VOEGELE; J. DAUMAL) et contribuera à l'affinement de la méthode de lutte (J. VOEGELE; N. HAWLITZKY; Université PARIS-SUD, XI, G. LAUGE. (17)

- Génétique du comportement de reconnaissance et d'oviposition de l'oophage (Département de Zoologie : ANTIBES : E. WAJNBERG; Laboratoire de génétique : Université de LYON : M. BOULETREAU).(18)(19)

- Mise en évidence, rôle et nature chimique de kairomones émanant de l'hôte sur le comportement de recherche et de reconnaissance de l'oophage (Département de Zoologie : VERSAILLES et U.N.C.A.A. N.HAWLITZKY; C. FRENOY; Département de Phytopharmacie : VERSAILLES : M. RENOU; P. NANIAN). (20)

- Mise au point de milieux artificiels et étude de l'oviposition et du développement des Trichogrammes sur ces milieux. Action de kairomones sur l'oviposition dans des oeufs artificiels (Département de Zoologie : LYON : S. GRENIER et G. BONNOT; VERSAILLES : N. HAWLITZKY et C. FRENOY; Département de Phytopharmacie : M. RENOU).

- D'autres travaux prenant place dans ces relations "insecte-insecte" portent sur le cortège parasitaire des Tachinidae de la pyrale du maïs (Département de Zoologie : P. ANGLADE; P.GALICHET (AVIGNON); S. GRENIER; N. HAWLITKZY; AGPM : B. NAIBO et sur la physiologie du développement de l'un d'entre eux dans son hôte naturel *O. nubilalis*. (S. GRENIER). (21)(22)

Relations "Insecte - Champignon pathogène"

Des études sont également conduites sur la pathogénécité de *Beauveria bassiana* sur la pyrale du maïs, sur la génétique des différentes souches, et son utilisation dans une lutte microbiologique contre les premiers stades larvaires. (Département de Zoologie : VERSAILLES - LA MINIERE : G. RIBA). (23)(24)

Cet ensemble cohérent de travaux de recherches doit permettre d'acquérir des connaissances de base sur le ravageur et ses ennemis naturels, d'expliquer les mécanismes régulant sa dynamique de population et son comportement et d'estimer l'importance des facteurs abiotiques et biotiques qui les régissent.

Ces connaissances entrent dans un objectif finalisé : pratiquer une lutte intégrée en culture de maïs, élaborée à partir de recherches approfondies et s'appuyant sur une modélisation de la dynamique de population du ravageur, sur l'analyse de certains de ses comportements et sur l'utilisation de méthodes de lutte biologique très élaborées.

REFERENCES

1. ANGLADE, P., DERRIDJ, S., KAAN, F., PANOUILLE, A., (1986). Progress in the studies of resistance to ECB (*O.nubilalis*) on maize in France. *Fourth meeting of the IOBC/WPRS Eucarpia working group breeding for resistance to insects and mites. Hundested, Denmark.* 23-25 septembre 1986.
2. ANGLADE, P., (1988). Comments Upon the Resistance and the Tolerance to the European Corn Borer of the Lines Tested in the IWGO Projects 1985-86 and 1987-88. *Proc. XVth Symp. Int. Working group on Ostrinia, Varna*, 167-170.
3. STENGEL, M., (1982). Essai de mise au point de la prévision des dégâts pour la lutte contre la pyrale du maïs (*Ostrinia nubilalis*) en Alsace (Est de la France). *Entomophaga*, 27, (n°HS) 105-114.
4. HAWLITZKY, N., (1986). Etude de la biologie de la pyrale du maïs, *Ostrinia nubilalis* Hbn. (Lep. *Pyralidae*) en région parisienne durant quatre années et recherche d'éléments prévisionnels du début de ponte. *Acta oecologica, Oecol. appl.* 7, 47-68.
5. GOT, B., et RODOLPHE, F., (1989) Temperature-dependent model for European corn borer (Lepidoptera : Pyralidae) development. *Environ. Entomol.*, 18, 85-93.
6. GOT, B., LAVENSEAU, L., PEYPELUT, L., GADENNE, C., (1989). Modélisation du cycle de la pyrale du maïs (*Ostrinia nubilalis*, Lepidoptera : Pyralidae). Illustration de deux niveaux de problèmes : la durée de développement larvaire et la diapause. *Ann. Soc. ent. Fr.*, 24, 396.
7. LABATTE, J.M., Modélisation de la distribution verticale des larves de pyrale, *Ostrinia nubilalis* Hbn., sur la plantde maïs. *Soumis en janvier 1990 à Journal of applied Entomology.*
8. GADENNE, C., PEYPELUT, L., LAVENSEAU, L., et GOT, B., (1987). Utilisation de critères métaboliques et morphogénétiques pour l'analyse de la diapause de populations naturelles d'*Ostrinia nubilalis* Hbn. *Agronomie*, 10, 769-777.
9. PEYPELUT, L., BEYDON, P. et LAVENSEAU, L., (1990). Ecdysteroids metabolism during diapause breakdown in the European corn borer. *Archive of Insect Biochemistry and Physiology*. Sous Presse.
10. GADENNE, C., GRENIER, S., PLANTEVIN, G. and MAUCHAMP, B., (1990). Effects of a juvenile hormone mimetic, fenoxycarb, on post-embryonic development of the European corn borer, *Ostrinia nubilalis* Hbn.*Experientia*, accepté.

11. ANGLADE, P., DERRIDJ, S., PANOUILLE, A., STOCKEL, J., (1986). Preference and non preference for oviposition of ECB females among field plots of experimental hybrids; p. 92-94. *Proceedings of the XIVth symposium of the international working group on Ostrinia nubilalis. Beijing, China, septembre 1986.*
12. DERRIDJ, S., FIALA, V., JOLIVET, E., (1987). Low molecular carbohydrates of *Zea mays* L. leaves and the egg-laying of *O.nubilalis* Hbn. Lep. *Pyralidae* p.295-299. In "*Labeyrie V., Fabres G., Lachaise D. ed.*"*Insects-Plants*".Junk Publishers, Dordrecht, 459 p.
13. DERRIDJ, S., GREGOIRE, V., BOUTIN, J.P., FIALA, V., (1989). Plant growth stages in the interspecific oviposition preference of the european corn borer and relations with chemicals present of the leaf surfaces. *Entomol. exp. appl.*, 53, 267-276.
14. THIERY, D., MASSON, C., (1986). Détection des signaux allélochimiques volatils et comportement des insectes phytophages. *In* : *Insectes, Insecticides, Santé*, ed. ACTA, 109-123.
15. MARION-POLL, F., (1986). La chimioréception chez la pyrale du maïs (*Ostrinia nubilalis* Hbn.) : approche anatomique et électroantennographique. 158 p. (Thèse Doct. Ingénieur "Sciences agronomiques", Institut National Agronomique Paris-Grignon).
16. HAWLITZKY, N., VOEGELE, J., STENGEL, M., REYNAUD, B., CROUZET, B., (1987). Utilisation de parasitoïdes oophages, les Trichogrammes dans la lutte contre la Pyrale du maïs. *Ostrinia nubilalis* Hbn. (Lepidoptera, Pyralidae) : méthodologie adoptée lors du passage de l'état expérimental à l'utilisation en vraie grandeur. *Conf. Int. sur les ravageurs en agriculture. Paris, 1, 2, 3 déc.1987. Ann. ANPP*, 6, II, 191-198.
17. RUSSO, J. et VOEGELE, J., (1982a). Influence de la température sur quatre espèces de Trichogrammes (Hym. *Trichogrammatidae*) parasites de la Pyrale du maïs *Ostrinia nubilalis* (Lep., *Pyralidae*). I. Développement préimaginal. *Agronomie* 2 (6), 509-516.
. RUSSO, J. et VOEGELE, J., (1982b). Influence de la température sur quatre espèces de Trichogrammes (Hym. *Trichogrammatidae*) parasites de la Pyrale du maïs *Ostrinia nubilalis* (Lep.*Pyralidae*). II Reproduction et survie. *Agronomie* 2 (6), 517-524.
18. WAJNBERG, E., (1989). Analysis of variations of handling-time in *Trichogramma maidis*. *Entomophaga* 34(3), 397-407.
19. CHASSAIN, C. et BOULETREAU, M., (1987). Genetic variability in the egg-laying behaviour of *Trichogramma maidis*. *Entomophaga* 32(2), 149-157.
20. RENOU, M., HAWLITZKY, N., BERTHIER, A., MALOSSE, C., RAMIANDRASOA, F., (1989). Mise en évidence d'une activité kairomonale des oeufs de la pyrale du maïs sur les femelles de *Trichogramma maidis*. *Entomophaga*, 34, 569-580.
21. GRENIER, S., ANGLADE, P., NAIBO, B., GALICHET, P.F., HAWLITZKY, N.. Enquête sur la répartition des Tachinaires (Dipt. Tachinidae) parasitoïdes de la pyrale du maïs *Ostrinia nubilalis* Hbn. (Lepidoptera, Pyralidae) en France (1985-87). *Entomophaga* (accepté par le comité de lecture).

22. RAMADHANE, A., GRENIER, S., PLANTEVIN, G., (1988). Photoperiod, temperature and ecdysteroid influencies on physiological interactions between diapausing *Ostrinia nubilalis* larvae and the tachinid parasitoid, *Pseudoperichaeta nigrolineata*. *Ent. exp. appl.* 48(3), 275-282.

23. RIBA, G., HSIU CHENG-FOUNG, X., GOUSSARD, J., (1987). Perspectives d'utilisation de l'hyphomycete *Beauveria bassiana* (Bals.) Vuill. contre la pyrale du maïs. *ANPP; Association nationale pour la Protection des Plantes; Paris* (FRA). *Conférence Internationale sur les ravageurs en Agriculture*. 12 p.

24. TADEUSZ, J., RIBA, G., WALKER, A.J., AIOUN, A., (1988). Variation in Isoesterase Profiles of Geographical Populations of *Beauveria bassiana* (Deuteromycotina : Hyphomycetes) isolated from *Sitona Weevils* (Coleoptera : Curculionidae). *Environmental Entomology* (USA). vol. 17 n° 2 , 275-279.