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A survey of potential vectors of apricot chlorotic leaf roll

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SUMMARY

A comparative survey was done in leafhopper populations captured in apricot orchards in two areas of Valencia, one with considerable natural spread of apricot chlorotic leaf roll (ACLR), and the other where such natural spread is virtually nonexistent. An identification of the leafhopper species found in the first and in the second area suggests that *Neoaliturus haematoceps* and/or *Neoaliturus fenestratus* are the potential vectors of ACLR, at least under the conditions of Valencia province. *Psammotettix striatus* and *Austroagallia sinuata* are potential secondary vectors of ACLR.

Additional key words : *Mycoplasma-like organisms, leafhoppers, natural spread.*

RÉSUMÉ

Prospection des vecteurs potentiels de l'enroulement chlorotique de l'abricotier.

Une étude comparative a été réalisée sur les populations de cicadelles capturées dans des vergers d'abricotier de deux zones de Valencia ; l'une d'elles montre une importante diffusion naturelle de l'enroulement chlorotique de l'abricotier (ACLR) et l'autre une diffusion naturelle pratiquement nulle. L'identification des espèces de cicadelles, trouvées en grande quantité dans la première zone et rares ou absentes dans la seconde, suggère *Neoaliturus haematoceps* et/ou *Neoaliturus fenestratus* comme vecteurs probables de l'ACLR, au moins dans les conditions de la région de Valencia. En second lieu, il faut aussi considérer *Psammotettix striatus* et *Austroagallia sinuata* comme éventuels vecteurs de l'ACLR.

Mots clés additionnels : *Organismes de type mycoplasme, cicadelles, diffusion naturelle.*

I. INTRODUCTION

Apricot chlorotic leaf roll (ACLR) is a disease initially attributed to a virus (MORVAN, 1957), and later associated with the presence of mycoplasma-like organisms (MLOs) in sieve tubes of diseased trees (MORVAN *et al.*, 1973 ; GOIDANICH *et al.*, 1980 ; PLOAIE, 1982). ACLR has been reported in France, Spain, Italy, Switzerland, Greece, Romania and Yugoslavia, causing decline and death to apricot, Japanese plum trees, and more rarely, to peach trees (MORVAN, 1977 ; LLÁCER, 1978).

Nearly all the known vectors of MLOs are leafhoppers (*Homoptera, Cicadellidae*) (FRITSCHE *et al.*, 1972). The leafhopper fauna had been previously studied in fruit orchards in the south of France (BONFILS *et al.*, 1976) and in eastern Spain (MEDINA *et al.*, 1981). The French authors found *Fieberiella florii* Stal to be a likely vector of ACLR. This species was the most abundant leafhopper in apricot orchards and had been described in the USA as an efficient vector for the MLO-induced peach X-disease. However, transmission tests with leafhoppers collected in areas affected by the disease or reared on diseased apricot trees gave negative results (BONFILS *et al.*, 1976). On the other hand, no specimen of *Fieberiella florii* was captured in the surveys conducted in Valencia and Murcia (MEDINA *et al.*, 1981), the two most important apricot-growing regions in Spain. This leafhopper species could, therefore, be rejected as the ACLR vector in Spain.

In order to narrow down the range of potential ACLR vectors in Spain, we re-examined our own previous epidemiology surveys (LLÁCER *et al.*, 1982). These surveys demonstrate a frequent incidence and spread of the disease in dry, moderately high areas (between 200 and 500 m) of the Valencia province. Conversely, the incidence of ACLR is insignificant and natural spread practically nonexistent in traditionally irrigated zones (citrus-growing areas) of the same province, about 50 km away from the previous areas.

The first purpose of the present study was to determine whether the differences in natural spread of ACLR has a causal relationship with the significant differences found in leafhopper populations. The second purpose was to determine the identity of the potential ACLR vector or vectors, so that future transmission tests can be conducted with better chances of success.

II. MATERIAL AND METHODS

Three orchards of 'Canino' apricot on apricot seedlings were selected at three locations in Valencia province : Bugarra, Liria and Carlet (the orchards were coded as BUG, LIR and CAR) (fig. 1). BUG is located at a height of 450 m within a dryland area with a considerable natural apread of ACLR. This orchard was maintained almost without tillage for the two last years under study, being consequently covered by a natural herbaceous weed flora. LIR is located at 280 m, in a dryland area with less natural spread of ACLR than in BUG. CAR, on the contrary, is located at 45 m, within a traditionally irrigated area with very few ACLR-diseased trees and without any apparent progression of the disease. In LIR and CAR conventional tillage practices were followed, thus allowing the soil to remain rather clean of herbaceous vegetation.

For the initial year, two yellow sticky traps (25 × 40 cm) were fastened to a tree trunk at ground level in each of the orchards. During the two subsequent years, four more traps were placed in each planting : two suspended from the tree canopies, at a height of 1.80 m, and the other two on the ground, over the orchard border. Each month the traps were replaced and the leafhoppers collected, identified and counted. Species identification was done by binocular microscopic examination of the male genital armature and of other external morphologic characters. The taxonomic criteria of RIBAUT (1936 & 1952) were followed and the systematics adopted were those of NAST (1972). The advantage of using yellow sticky traps over other sampling methods were reported by PURCELL & ELKINTON (1980).

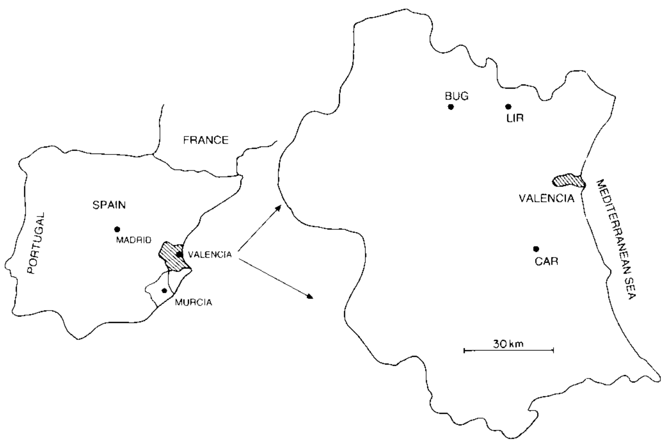

Figure 1

Location of Valencia and Murcia, the two most important apricot-growing regions in Spain, and location of the three orchards studied within the province of Valencia.

Situation géographique de Valencia et Murcia, les 2 régions espagnoles les plus importantes pour la culture de l'abricotier, et emplacement des 3 vergers étudiés dans la région de Valencia.

III. RESULTS

Throughout the three-year experiment, 60 species of leafhoppers were captured, in very variable numbers, in addition to very small numbers of 8 species of other *Homoptera Auchenorrhyncha* (planthoppers and froghoppers). A complete list of the species caught has already been published (LLÁCER *et al.*, 1986).

Tables 1 and 2 show a comparison between the number of species and of specimens captured in each of the

TABLE 1

Comparison between the number of leafhopper species captured in an area with considerable ACLR spread (orchards BUG and LIR) and another area where ACLR spread is almost nonexistent (CAR).
a : *ground level (tree foot)* ; b : *1.80 m above ground level* ; c : *ground level (orchard border).*

Comparaison entre la quantité d'espèces de cicadelles capturées dans une zone avec une diffusion appréciable de l'ACLR (vergers BUG et LIR) et une autre zone où la diffusion de l'ACLR est presque nulle (CAR).
a : *niveau du sol (pied d'arbre)* ; b : *1,80 m d'hauteur* ; c : *niveau du sol (bordure du verger).*

No. species		1982	1983			1984			Total (*)
		a	a	b	c	a	b	c	
Sub-family *Typhlocybinae*	BUG	12	11	9	9	8	7	10	13
	LIR	15	10	9	10	8	6	11	15
	CAR	9	6	8	5	7	8	1	10
Other Sub-families	BUG	20	26	22	24	22	14	22	35
	LIR	27	22	11	26	13	8	13	34
	CAR	13	10	5	10	9	1	5	14
Total	BUG	32	37	31	33	30	21	32	48
	LIR	42	32	20	36	21	14	24	49
	CAR	22	16	13	15	16	9	6	24

(*) No of distinct species.

TABLE 2

Comparison between the number of leafhopper specimens captured in an area with considerable ACLR spread (orchards BUG and LIR) and another area where ACLR spread is almost nonexistent (CAR).
a : *ground level (tree foot)* ; b : *1.80 m above ground level* ; c : *ground level (orchard border).*
Comparaison entre la quantité de cicadelles capturées dans une zone avec une diffusion appréciable de l'ACLR (vergers BUG et LIR) et une autre zone où la diffusion de l'ACLR est presque nulle (CAR).
a : *niveau du sol (pied d'arbre)* ; b : *1,80 m d'hauteur* ; c : *niveau du sol (bordure du verger).*

No. specimens		1982	1983			1984			Total
		a	a	b	c	a	b	c	
Sub-family *Typhlocybinae*	BUG	332	3 607	4 508	3 827	445	682	587	13 988
	LIR	3 715	831	1 205	1 054	357	410	483	8 055
	CAR	595	497	651	22	443	673	82	2 963
Other Sub-families	BUG	407	1 001	619	1 512	568	538	871	5 516
	LIR	1 025	864	169	248	245	79	93	2 723
	CAR	441	261	9	85	249	6	49	1 100
Total	BUG	739	4 608	5 127	5 339	1 013	1 220	1 458	19 504
	LIR	4 740	1 695	1 374	1 302	602	489	576	10 778
	CAR	1 036	758	660	107	692	679	131	4 063

three orchards studied. These tables show a distinction between the sub-family *Typhlocybinae* and the other sub-families of leafhoppers, since the number of specimens of *Typhlocybinae* caught was far larger than that of the other sub-families combined. Although the number of captured specimens varied greatly from one year to another, data in Tables 1 and 2 indicate that the total number of species and of specimens collected in the orchards having natural spread of ACLR (BUG and LIR) was considerably larger than in the planting without natural spread (CAR). The number of species collected in BUG and in LIR was similar (table 1), whereas the number of specimens was nearly always larger in BUG (table 2), a fact that could be attributed to the abundance of natural herbaceous vegetation in this orchard.

The non-*Typhlocybinae* (NT) leafhoppers most abundantly found in BUG and in LIR are listed in table 3. Out of the six species, two were not found in CAR, and the other four were collected in very small

TABLE 3

Number of specimens of the six leafhopper species (non Typhlocybinae) *most abundant in the orchards BUG and LIR (and absent, or almost nonexistent, in CAR).*
a : *ground level (tree foot)* ; b : *1.80 m above ground level* ; c : *ground level (orchard border).*
Nombre de cicadelles (non Typhlocybinae) *des 6 espèces les plus nombreuses capturées aux vergers BUG et LIR (et absentes, ou en très petit nombre, à CAR).*
a : *niveau du sol (pied d'arbre)* ; b : *1,80 m d'hauteur* ; c : *niveau du sol (bordure du verger).*

Leafhopper species		1982	1983			1984			Total
		a	a	b	c	a	b	c	
Neoaliturus	BUG	548	356	97	464	206	55	226	1 952
haematoceps	LIR	31	614	57	67	136	18	21	944
(M.-R.)	CAR	4	9	2	2	0	0	0	17
Neoaliturus	BUG	8	56	180	157	61	323	189	974
fenestratus	LIR	21	22	66	18	2	15	6	150
(H.-S.)	CAR	0	0	0	0	0	0	0	0
Grypotes	BUG	11	187	209	193	62	38	67	767
staurus	LIR	16	28	22	17	21	31	1	136
(Iv.)	CAR	14	2	1	1	1	0	0	19
Psammotettix	BUG	43	42	12	9	89	10	15	220
striatus	LIR	197	43	11	42	37	5	46	381
(L.)	CAR	6	2	1	2	4	0	1	16
Austroagallia	BUG	20	90	6	200	63	3	91	473
sinuata	LIR	4	51	3	4	11	3	1	77
(M.-R.)	CAR	1	0	0	0	0	0	0	1
Platymetopius	BUG	1	35	1	58	4	0	22	121
rostratus	LIR	7	10	0	5	1	0	4	27
(H.-S.)	CAR	0	0	0	0	0	0	0	0

numbers. Some *Typhlocybinae* species were more abundant in BUG and in LIR than the six mentioned in table 3, but were equally abundant in CAR.

Neoaliturus haematoceps (Mulsant-Rey), of the sub-family *Deltocephalinae,* a typical species occurring in arid and semi-arid zones, was the non-*Typhlocybinae* (NT) leafhopper caught in larger numbers in BUG and LIR, whereas in CAR it appeared to be almost non-existent, thus confirming the results of HERMOSO DE MENDOZA & MEDINA (1979) who were able to capture only two specimens during their survey of leafhoppers in citrus orchards in the Valencia area.

Neoaliturus fenestratus (Herrich-Schaffer) was the (NT) species ranking second as far as the number of captures in BUG and in LIR is concerned. Not even one specimen was found in CAR. In contrast to *N. haematoceps, N. fenestratus* was caught in larger numbers with the traps hanging from the trees canopies than with the traps placed on ground level.

Grypotes staurus Ivanoff, *Psammotettix striatus* (L.) and *Platymetopius rostratus* (Herrich-Schaffer), the 3rd, 4th and 6th (NT) species caught in larger numbers in BUG and LIR, also are from the sub-family *Deltocephalinae.* Conversely, *Austroagallia sinuata* (Mulsant-Rey), the 5th (NT) species collected in larger numbers in BUG and in LIR, belongs to the *Agallinae* sub-family.

IV. DISCUSSION

Our results suggest that there is a correlation between occurrence of natural spread of ACLR and number of leafhoppers captured. It has also been substantiated that the non-*Typhlocybinae* (NT) leafhopper species most abundant in orchards with considerable spread of the disease were not found (or only in a very small number) in the planting where there is no natural spread.

Interestingly, the six (NT) leafhopper species most abundant in BUG and in LIR (table 3) are also among the thirteen caught in larger numbers by BONFILS *et al.* (1976) in apricot orchards in the south of France, which implies that any of them could be an ACLR vector in the two countries. *Fieberiella florii* (the species most abundantly occurring in France) has never been captured in Spain. *Euscelidius variegatus* (2nd captured in larger numbers in France) was the (NT) leafhopper most abundant in CAR (750 specimens), whereas it was not caught at all in BUG and only 9 specimens were collected in LIR. This leafhopper should therefore be disregarded as an ACLR vector in Valencia.

One may pose the question as to whether there is any criterion (apart from abundance) to evaluate which one of the six species is a potential vector of ACLR. Examining the list of leafhopper vectors of virus and mycoplasma organisms (FRITSCHE *et al.,* 1972), it can be inferred that there seem to exist leafhopper genera with a special transmissive ability for mycoplasmas and, when a species is a MLO vector, it is able to transmit more than one disease. Of the six species shown in table 3, neither *Grypotes staurus* nor *Platymetopius rostratus* (nor any species of the genera *Grypotes* and *Platymetopius*) are cited as vectors of virus or mycoplasmas. *Psammotettix striatus* has been cited by FRITSCHE *et al.* (1972) as a virus vector, and other species of *Psammotettix* are cited by the same authors as vectors of diseases associated with MLOs. *Austroagallia* (= *Peragallia*) *sinuata* is also cited by FRITSCHE *et al.* (1972) as vector of a mycoplasma-like disease (potato witches'broom).

Recently, FOS *et al.* (1986) have shown that *Neoaliturus haematoceps* is able to acquire *Spiroplasma citri* from infected periwinkles. The spiroplasma multiplies in its body and can be transmitted to healthy plants. This result and the presence of *N. haematoceps* in several citrus-producing Mediterranean countries suggest that this leafhopper is a vector of citrus stubborn in the Mediterranean basin, playing the same role as *Neoaliturus* (= *Circulifer*) *tenellus* in California (BOVÉ, 1986). *Neoaliturus fenestratus* is a species close to the two previous ones and could have similar transmissive ability.

Other species cited by FRITSCHE *et al.* (1972) as vectors of mycoplasma-like diseases, such as leafhoppers *Macropsis fuscula* (Zett.), *Macrosteles quadripunctulatus* (Kirschb.), *Euscelidius variegatus* (Kirschb.) and *Euscelis lineolatus* Brulle, planthopper *Hyalesthes obsoletus* Sign. and froghopper *Philaenus spumarius* L., were also captured in BUG and in LIR, although in very small numbers. Some of these species, namely *Macrosteles quadripunctulatus* and *Euscelidius variegatus,* were more abundant in CAR than in BUG and in LIR. None of the *Typhlocybinae* captured has been implicated as vector of mycoplasma organisms. In addition, most authors admit a lack of ability of *Typhlocybinae* in transmitting MLOs, a fact attributed to feeding habits (BONFILS *et al.,* 1976).

Applying the criteria of abundance and transmissive ability of MLOs, we can draw the conclusion that the species with the greatest probability of being vectors of ACLR, at least under the conditions of Valencia, are *Neoaliturus haematoceps* and/or *Neoaliturus fenestratus.* In the second place, *Psammotettix striatus* and *Austroagallia sinuata* can be regarded as potential vectors of ACLR. Transmission tests using these species should be given priority, since they are the only means definitely to prove the nature of the vector.

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