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Implementing a Geographical Information System (GIS) for pepper greenhouse natural enemy and pest management in Southeast Spain

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Abstract: Biological pest control is applied in 90% of protected pepper crops in Campo de Cartagena (Southeast Spain). The quick transition from chemical to biological pest control methods was motivated in part by problems in controlling western flower thrips, *Frankliniella occidentalis,* using pesticides. Decision-making in greenhouses under biological pest control is based on periodical sampling that generates a great amount of information which can be stored and analysed using Geographical Information Systems (GIS). The aim of this work was to show the application of GIS in optimising management strategies in greenhouse pepper crops; *Orius laevigatus* release was analysed in relation to *F. occidentalis* and *Orius* spp. spatio-temporal population dynamics. Thrips and *Orius* spp. population abundance data were gathered weekly for 137-412 greenhouses in a 64 square km area. Greenhouses were located using Global Positioning System (GPS) and satellite digital images. Inverse distance weighted (IDW) interpolation was performed to estimate *F. occidentalis* and *Orius* spp. incidence at non-sampling points. *F. occidentalis* and *Orius* spp. showed an uneven geographical abundance distribution through time. High *F. occidentalis* incidence (percentage of occupied flowers) was in correspondence with areas of late *O. laevigatus* establishment. *O. laevigatus* was realeased during April, May and June in areas were it was already successfully established. GIS may be used to optimise *O. laevigatus* releases according to population dynamics.

Key words: *Frankliniella occidentalis, Orius spp.*, integrated pest management, geographic information systems, GIS, spatial interpolation.

Introduction

Biological pest control and integrated pest management (IPM) strategies have been almost generally adopted in greenhouse pepper crops in Campo de Cartagena (Southeast Spain). In less than ten years 90% of protected pepper crops (about 1600 ha) switched from chemical to IPM and Biological pest control (Sanchez & Lacasa, 2006). The quick transition from chemical to IPM programs was due among other reasons to: (1) increasing difficulties to satisfactorily control western flower thrips [*Frankliniella occidentalis* (Pergande)] using pesticides and the high Tomato spotted wilt virus (TSWV) incidence; (2) restrictions in pesticide application following the European Union normatives.

The change in pest control strategies brought in a new decision-making concept based on periodical sampling (Sanchez *et al.,* 1997). *F. occidentalis* is the key pest and its populations are carefully monitored almost during the entire growing season. *Orius laevigatus* (Fieber) is a key predator released for *F. occidentalis* control according to thrips and *Orius* spp. population dynamics (Sanchez & Lacasa, 2002). Although only *O. laevigatus* is used in augmentative releases, *Orius albidipennis* (Reuter) spontaneously colonize the crops and it usually represents the most abundant species during summer months (Sanchez *et al.*, 1997). This weekly sampling scheme generates a big amount of poorly utilised information as it is

uniquely used for immediate decision-making purposes. The proper storage and analysis of this information may revert in optimising IPM practices. Geographic Information Systems (GIS) may be used to store and analyse this information spatially (Liebhold *et al.*, 1993).
The aim of this work was to show how GIS can be used as a management tool to optimise IPM practices. In this work we analyse the spatio-temporal evolution of *F. occidentalis* and *Orius* spp. We also discuss *O. laevigatus* release strategies in relation to thrips and anthocorid population dynamics.

Material and methods

Area of study

Campo the Cartagena is a flat area located along the coastal strip of Murcia and Alicante regions. The study area was circumscribed to a 8.5x7.5 km cell located in the northern part of Campo de Cartagena (Figure 2).

Table 1. Number of greenhouses used in the analyses and number of greenhouses where *Orius laevigatus* was released during the first two weeks of each month.

Month	Jan		Feb		Mar		Apr		May		Jun
Week	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st
Orius	213	137	144	261	288	275	338	341	308	412	311
Thrips	343	187	196	316	322	308	338	341	308	412	311
Orius releases	71	85	98	141	80	45	58	55	33	45	6

Population dynamic information

Orius laevigatus releases and *F. occidentalis* and *Orius* spp. abundance data (percentage of occupied flowers) data were gathered weekly by IPM technicians. Thrips and *Orius* spp. abundance for each greenhouse was given as the average of two weeks in each month. The average of all greenhouses was used to calculate the population dynamics of *F. occidentalis* and *Orius* spp. We used *Orius* spp. when describing population dynamics because *O. albidipennis* usually immigrates and establishes in pepper crops. Greenhouses were located using global positioning system (GPS) and satellite digital images (Figure 2). The number of greenhouses used in the analyses and *O. laevigatus* releases are specified in Table 1.

Spatial interpolation

Inverse distance weighted (IDW) interpolation was performed to estimate *F. occidentalis* and *Orius* spp. incidence at non-sampling points (100x100 m grid) using ArcView GIS (ESRI®)-Spatial Analyst extension. All analysis were done using the R statistical software (R Development Core Team, 2004).

Results and discussion

Temporal evolution

The percentage of occupied flowers by *F. occidentalis* progressively increased from January to mid May and slowly decreased thereafter (Figure 1). *O. laevigatus* population increased at the same rate as *F. occidentalis* until mid March and at a much higher rate in the following weeks; at the end of June almost 80% of the flowers were occupied with *Orius* spp. Most *O. laevigatus* releases were done between January and the end of March (Figure 1), and only a quarter of the releases (28%) were carried out between April and mid June.

Orius spp. and *F. occidentalis* population dynamics in Campo de Cartagena during 2005 was very characteristic and similar to what was observed in previous years (Sanchez *et al.*, 1997). Western flower thrips is usually present in most greenhouses at the beginning of the growing season but its populations remain low during winter months due to low temperatures (Sanchez *et al.*, 2000). In most greenhouses population outbreaks occur between mid April and the beginning of June (Sanchez *et al*., 2002).

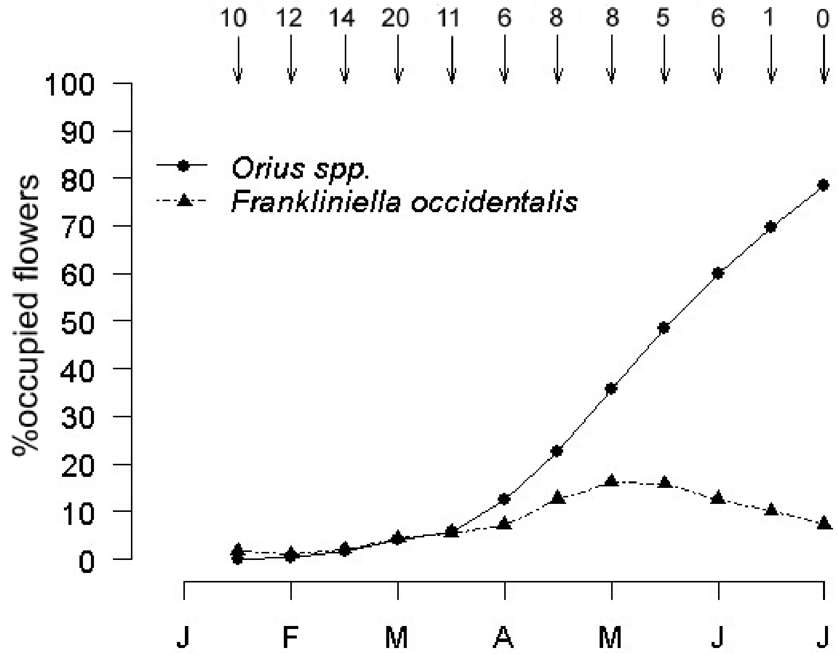

Figure 1. Population dynamics of *F. occidentalis* and *Orius* spp. in pepper greenhouses during 2005. The arrows indicate the moment of releases and the upper numbers the percentage of releases in relation to the total in the growing season.

Spatio-temporal dynamics

The spatio-temporal analysis showed an uneven geographical distribution of *F. occidentalis* and *Orius* spp. abundance over time (Figure 2). The abundance of *F. occidentalis* during January was null through the entire working area. At the beginning of February *F. occidentalis* was already present in the northern area, but its population remained stable until March. In April *F. occidentalis* spread through all the territory and hotspots were registered during May and June. The overall thrips incidence was higher for the northern than for the southern part (Figure 2).

The first *O. laevigatus* establishment spots were observed in February. At the beginning of March, *O. laevigatus* was already established through a big area in the lower part of the map (Figure 2). In April the bug was present in all the territory but its abundance was higher in places with early establishment. The higher *O. laevigatus* flower occupancy (76-100%) was reached during June (Figure 2).

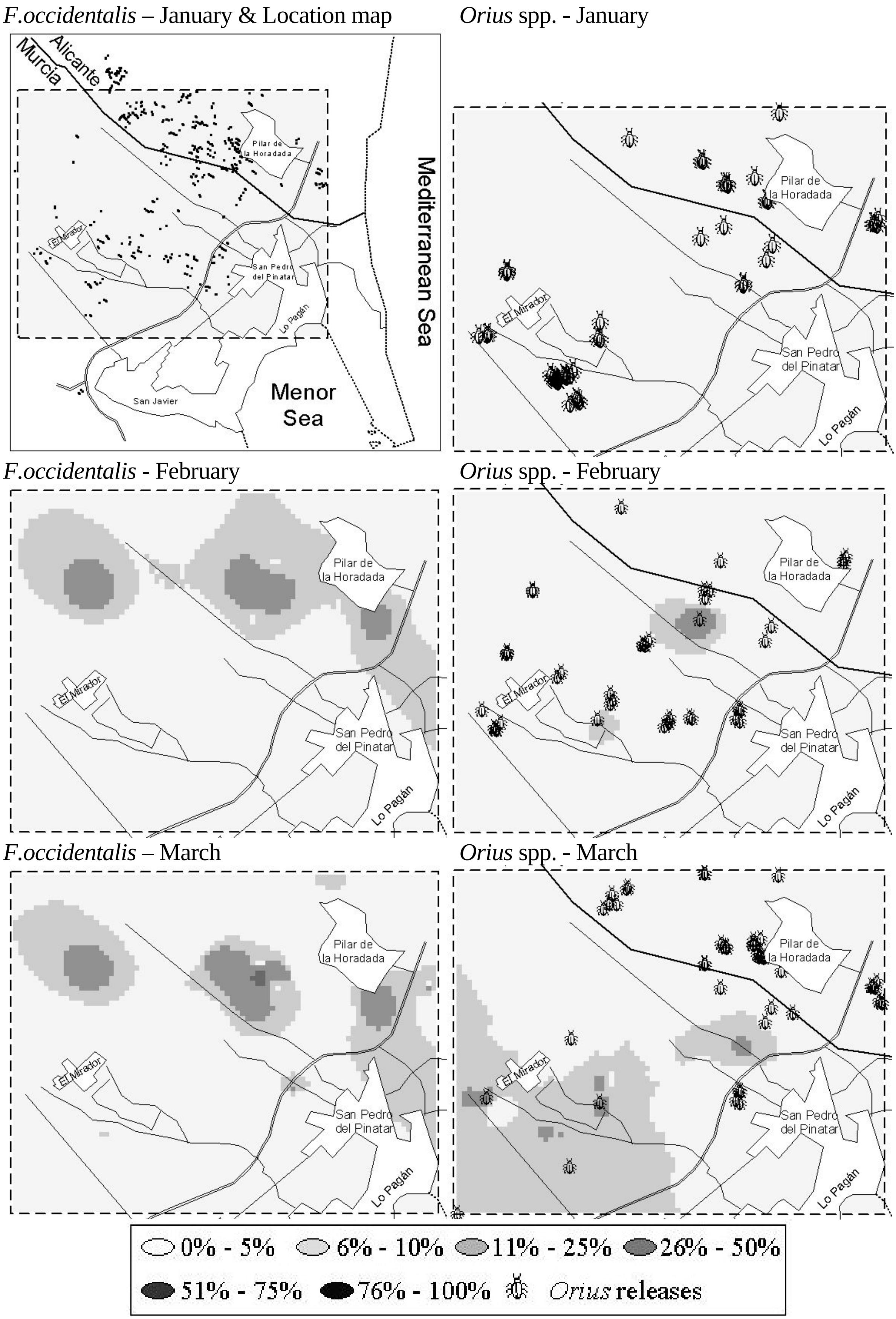
F.occidentalis – January & Location map
Orius spp. - January
F.occidentalis - February
Orius spp. - February
F.occidentalis – March
Orius spp. - March
Alicante
Murcia
Mediterranean Sea
Menor Sea
Pilar de la Horadada
El Mirador
San Pedro del Pinatar
Lo Pagán
San Javier
0% - 5%
6% - 10%
11% - 25%
26% - 50%
51% - 75%
76% - 100%
Orius releases

Figure 2.

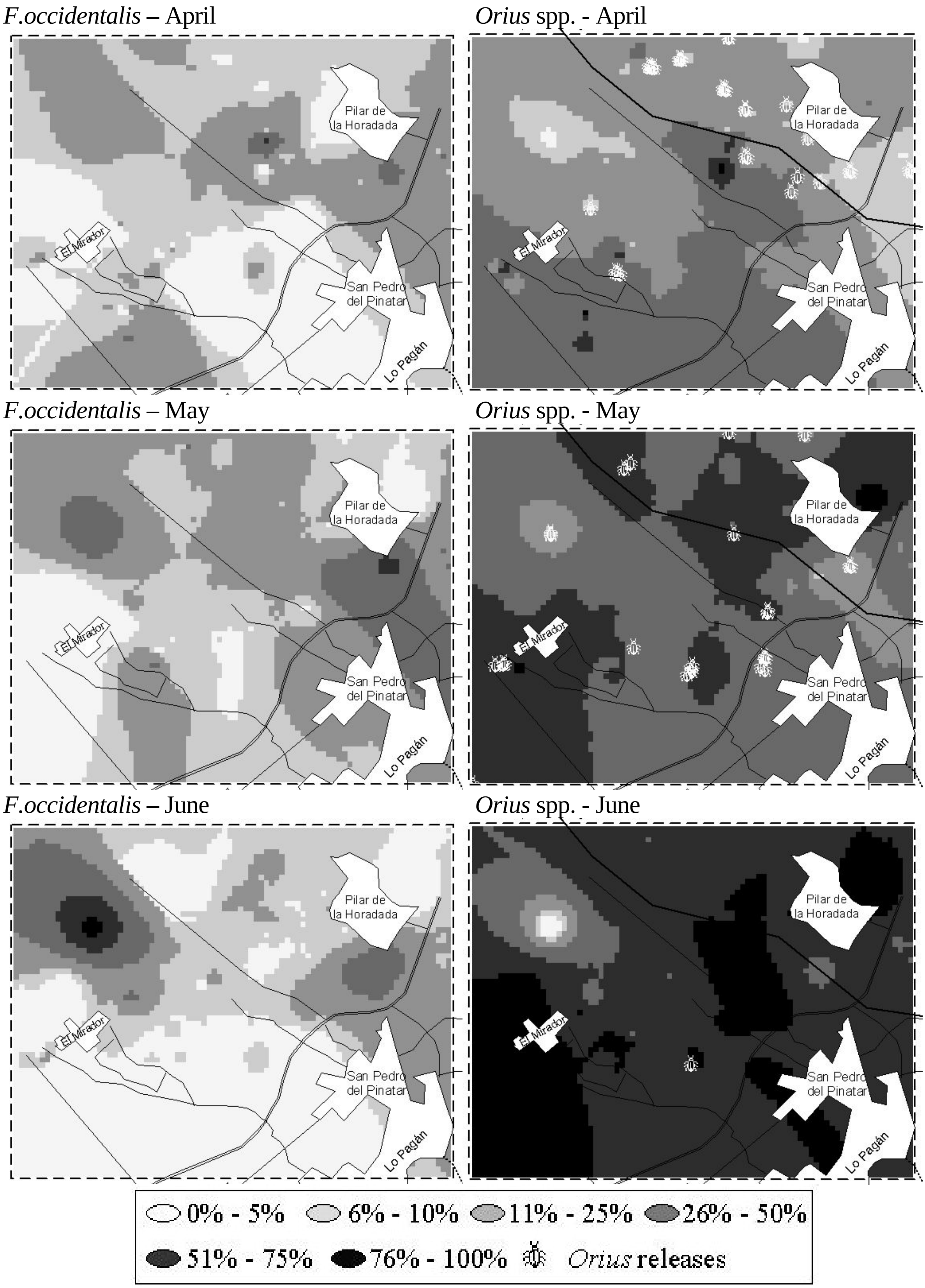

Figure 2 (continued). Interpolated surfaces of *Orius* spp. and *F. occidentalis* abundance: average of the percentage of occupied flowers in the first two weeks of each month. The dashed square in the very first map shows the study area; dots represents all greenhouses used in spatial interpolations.

O. laevigatus *release strategies*

Although *O. laevigatus* was abundantly released from January to May, timing was different from one area to the other (Figure 2). Early releases in January were effectuated in greenhouses through the entire territory. In February the intensity of releases was higher in the middle and lower part, while in March, it was more intense at the upper right corner. Most of the releases during April, May and June were done in areas where *Orius* spp. abundance was already high (Figure 2).

The failure in early *Orius laevigatus* establishment and the absence of releases in thrips hotspots during February may have greatly determined the higher thrips incidence in greenhouses at the upper area (Figure 2). Releases in these areas should be optimised in order to accomplish a more efficient thrips control. The lack of establishment in some of the northern areas might as well be a consequence of bad crop practices interfering with the activity of *Orius* spp. During April, May and June most *O. laevigatus* was released in areas where it was already successfully established. Avoid releasing *O. laevigatus* in areas where it were already established would significantly reduce the cost of IPM programs.

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