Evaluation of the Efficacy of an Insecticidal Paint Based on Chlorpyrifos and Pyriproxyfen in a Microencapsulated Formulation Against *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae)

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J. Econ. Entomol. 103(2): 402–408 (2010); DOI: 10.1603/EC09310

ABSTRACT The weevil *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) is an important pest of palms. It has recently colonized the Mediterranean Basin where it is a serious problem on ornamental *Phoenix canariensis* (hort. ex Chabaud) palms. The efficacy of an insecticidal paint based on chlorpyrifos and pyriproxyfen in a microencapsulated formulation (Inesfly IGR FITO, Industrias Químicas Inesba S.L., Paiporta, Spain) against this weevil has been studied. Laboratory results proved that pyriproxyfen has no effect against *R. ferrugineus* when applied in this microencapsulated formulation. Semifield trials dismissed Inesfly IGR FITO as a curative insecticide but showed the potential of this product in the preventative control of *R. ferrugineus* in palms. One single application could prevent infestation for up to 6 mo with a mean efficacy of 83.3%.

RESUMEN *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae), es una importante plaga de palmeras. Recientemente ha invadido la Cuenca Mediterránea, donde se ha convertido en una grave problema para la palmera ornamental *Phoenix canariensis* (hort. ex Chabaud). Se ha estudiado la eficacia contra este coleóptero de Inesfly IGR FITO (Industrias Químicas Inesba S.L., Paiporta, Spain), una pintura insecticida con clorpirifos y piriproxifén en formulación microencapsulada. Los resultados de laboratorio probaron que piriproxifen no tiene efecto sobre *R. ferrugineus* cuando se aplica mediante este formulado. Los resultados de semi-campo descartaron Inesfly IGR FITO como insecticida curativo pero probaron el potencial de este producto en el control preventivo de *R. ferrugineus* sobre palmeras. Una sola aplicación puede prevenir su infestación durante un periodo de hasta seis meses con una eficacia media de 83.3%.

KEY WORDS *Rhynchophorus ferrugineus*, Inesfly IGR FITO, palm, *Phoenix conariensis*

Rhynchophorus ferrugineus (Olivier) (Coleoptera: Curculionidae) is a phytophagous insect that feeds in soft succulent tissues of many palm species (Barranco et al. 2000, Dembilio et al. 2009a). Females deposit their eggs in separate holes or injuries at the base of the fronds. Eggs hatch into legless larvae that bore into the palm core. Larvae are the most destructive stage of the weevil as they can penetrate deep in the stem damaging its internal tissues. On completion of their development, larvae pupate in elongate oval, cylindrical cocoons made out of fibrous strands. The weevil is a concealed tissue borer and can spend all of its life stages inside the palm. Adults often remain and reproduce within the same host until the apical growing area of the palm has been destroyed causing the palm to die. The complete life cycle of the weevil, from egg to adult emergence, takes an average of 82 d (Murphy and Briscoe 1999). Infested palms do not show any obvious early symptoms, and usually the pest is detected only after most damage has been inflicted (Kehat 1999).

Currently, *R. ferrugineus* is the major pest of palms in the Middle East and the Mediterranean (Llácer et al. 2009). This invasive weevil, which is native of South and Southeast Asia, was first detected in Egypt in date palms, *Phoenix dactylifera* L., in 1992 (Cox 1993). In Spain, *R. ferrugineus* was detected in 1995 (Barranco et al. 1995) but remained confined in a small area in southern Spain until 2004, when the pest appeared in different foci along the Spanish Mediterranean coast. In 2006 it was reported in the Canary Islands. Today, it can be found in almost all Mediterranean countries (EPPO 2008). In 2008, it was discovered for the first time in the Americas (EPPO 2009) where it may become a serious pest. In all these areas, *R. ferrugineus* constitutes a severe pest of the Canary

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palm, *Phoenix canariensis* (hort. ex Chabaud), which is an important ornamental plant in both public and private gardens. Furthermore, the original wild populations of this species located in the palm forests existing in the Canary Islands are presently at risk.

Many preventative and curative procedures have been designed with more o less success to limit and contain the spread of an infestation (Faleiro 2006), but recent concern about the side effects of chemical pesticides on the environment has resulted in the restriction in the use of a large extent of them. In addition, because of the concealed nature of the larvae, effective methods for the management of the *R. ferrugineus* have been difficult to develop and insecticides have to be applied frequently and over a long period for effective management of established populations (Murphy and Briscoe 1999, Ferry and Gómez 2002).

Inesfly IGR FITO (Industrias Químicas Inesba S.L., Paiporta, Spain) is an insecticidal paint (active ingredients 3.0% chlorpyrifos and 0.063% pyriproxyfen) in a microencapsulated formulation. Pyriproxyfen [2-[1-methyl-2-(4-phenoxyphenoxy) ethoxy]pyridine] is an insect growth regulator (IGR) belonging to the juvenile hormone mimic class. It has low toxicity to mammals, fishes, and birds. Laboratory tests carried out on pupae of *R. ferrugineus* with other IGRs (Lufenuron and Diofenolan) (Ghoneim et al. 2003) showed that treatment affected the general body metabolism, changing carbohydrate, protein, and lipid content, but how it affected *R. ferrugineus* survival was not tested. Chlorpyrifos [phosphorothioic acid, *O,O*-diethyl-*O*-(3,5,6-trichloro-2-pyridinyl) ester] is a toxic crystalline organophosphate insecticide that inhibits acetylcholinesterase. It is considered harmful for fishes but only moderately toxic to both bees and birds. This active ingredient affected *R. ferrugineus* when used trough coordinated foliar spraying and trunk injection in single or repeated application (Hernández-Marante et al. 2003).

Inesfly IGR FITO is a polymer composed of two parts: 1) vinyl acetate that gives the polymer its consistence and its capacity of carrying active ingredients; and 2) versaic acid ester VeoVa that provides wet scrub and photolytic resistance. This microencapsulated formulation confers the advantage of releasing active ingredients slowly, so paint does not have to be applied frequently and its effect can last for a long time (López et al. 1999, Mosqueira et al. 2005, Dias and Jemmio 2008, Amelotti et al. 2009). Another formulation of this polymer (Inesfly 5A IGR; [AI] 1.5% diazinon, 1.5% chlorpyrifos, and 0.063% pyriproxyfen) has performed satisfactorily against other pests of human concern. This product showed high efficacies for up to 12 mo against *Triatoma infestans* Klug (Hemiptera: Reduviidae), the main vector of Chagas disease in the heavily infested region of the Bolivian Chaco (Dias and Jemmio 2008, Amelotti et al. 2009). Other studies (López et al. 1999, Mosqueira et al. 2005) showed that this formulation was able to prevent infestation by *Periplaneta americana* L. (Dictyoptera: Blattidae) and *Culex quinquefasciatus* Say (Diptera: Culicidae) for up to 24 and 12 mo, respectively.

The objective of this study was to determine the efficacy of Inesfly IGR FITO against *R. ferrugineus.* A series of laboratory assays were performed to determine its effect on both adults and immature stages of this species. Simultaneously, a semifield study including both preventative and curative treatments on young palms was carried out.

Materials and Methods

The assays reported in this study were carried out at the Institut Valencià d'Investigacions Agràries (IVIA, Montcada, Spain). Laboratory trials took place in a climatic cabinet at 25 ± 2°C, 80 ± 10% RH, and a photoperiod of 16:8 (L:D) h. Semifield trials were performed in a double mesh security enclosure containing 24 independent cages (4 by 3 by 3 m) under natural light and temperature conditions during summer–fall 2008. Mean temperature during the assays was 23.7°C (max, 34.2°C; min., 10.7°C). A plastic roof protected the enclosure from the rain.

Experimental Insects. Laboratory tests were carried out on eggs, 15- and 60-d-old larvae (young and almost mature larvae, respectively), and 1-wk-old adults of *R. ferrugineus.* To obtain enough individuals of these stages, wild adults were captured in the province of Valencia (eastern Spain) in traps baited with ferrugineol (male aggregation pheromone) and plant kairomones (ethyl acetate and pieces of palm fronds). These adults were kept in plastic boxes and offered thin slices of red apple 'Starking delicious' both as food and as oviposition substrate. Wild adults were replaced monthly. After hatching neonate larvae were reared on an artificial diet (Martín and Cabello 2006) until they reached the developmental stage required for our assays. Seventy-day-old larvae were individually introduced in 100-ml vials half filled with esparto grass fibers to promote cocoon formation. One month later, adults emerged from cocoons.

Wild adults directly obtained from traps were used to infest the palms in the preventative tests. Before release those adults were kept for 3 d in a plastic lunch-box with a perforated lid where thin apple slices were provided as food source. The 3-d-old larvae used in curative tests were obtained as described above.

Plant Material. Semifield trials were performed on 72 4-yr-old potted *P. canariensis* palms obtained from an officially inspected nursery (EU 2007) and therefore were presumed to be free of *R. ferrugineus.* The stipe of these palms was 0.35–0.55 m in height and 0.30–0.40 m in width. Plants were watered twice a week.

Laboratory Assays. *Adults.* Four paint formulations were considered: 1) paint with no active ingredient, 2) paint with 3.0% chlorpyrifos, 3) paint with 0.063% pyriproxyfen, and 4) complete paint with 3.0% chlorpyrifos and 0.063% pyriproxyfen. Exposure took place in ventilated plastic boxes (11 by 14 by 7 cm). Their bottom (154 cm^2) was painted 24 h before the introduction of the insects with a deposit of 170 g/m^2. Ten

Table 1. Effect of different paint treatments on the mortality (percentage) and the reproductive parameters (mean ± SEM) of *R. ferrugineus* adults in laboratory assays

Treatment	Mortality (n = 20)		Reproduction (n = 10)		
	2 d	20 d	Total fecundity (eggs/female)	Daily fecundity (eggs/female day)	Egg hatching (%)[a]
Control	0	20	9.1 ± 2.5a	2.0 ± 0.3a	75.0 ± 7.1a
Paint 1 (no [AI])	0	10	9.4 ± 1.5a	2.2 ± 0.2a	78.4 ± 4.5a
Paint 2 (3% chlorpyrifos)	100				
Paint 3 (0.063% pyriproxyfen)	0	5	10.9 ± 2.0a	2.0 ± 0.2a	65.3 ± 4.1a
Paint 4 (complete Inesfly IGR Fito)	100				
ANOVA (F; df; P)			0.25; 2, 27; 0.7836	0.23; 2, 27; 0.7972	1.98; 2, 23; 0.1608

Within a column, means followed by the same letter are not significantly different from each other ($P < 0.05$; LSD test).
[a] Only female's offspring with more than one hatched egg were subjected to analysis.

replicates of one couple per paint formulation and an untreated control were considered. During 20 d, a thin slice of Starking delicious red apple was offered both as food and as oviposition substrate and replaced every 2 d. When changed, the apple slices were checked for presence of eggs that were counted and kept in a petri dish to assess egg hatching.

Immature Stages. The effect of the complete paint on survival of *R. ferrugineus* immature stages (eggs and both 15- and 60-d-old larvae) was tested. *Eggs.* Exposure took place in unsealed petri dishes 5.5 cm in diameter with the bottom painted as described above. Less than 24-h-old eggs were placed in groups of 20 onto the painted surface. Apple slices and 1- by 1-cm cubes of artificial diet were provided as food source for neonate larvae. Egg hatching and neonate survival were recorded daily. A control treatment was included and each treatment was replicated four times. *Fifteen-day-old larvae.* Exposure took place in 100-ml vials. Their bottom was painted as before and the vials were half filled with artificial diet. Ten replicates of five larvae per treatment and control were considered. Mortality was recorded daily until molting. *Sixty-day-old larvae.* Exposure took place in groups of five larvae in unsealed petri dishes 5.5 cm in diameter painted as before. Twenty-four hours later, the five larvae were transferred to a 100-ml vial half filled with diet. Ten replicates of five larvae per treatment and control were considered. Mortality was recorded daily until molting.

Semifield Assays. A semifield study, including both preventative and curative assays, was carried out to evaluate the efficacy of Inesfly IGR FITO against *R. ferrugineus* in young palm trees.

Preventative Assays. Twenty-one uninfested palms were painted with 300 ml of Inesfly IGR FITO per palm so that both the outer stipe and the base of fronds were completely coated. Twenty-one additional palms constituted the control treatment. Four days after product application, three control palms and three treated palms were individually exposed to three presumably mated females of *R. ferrugineus* per plant in separate cages. One week later, when found, females were removed from the cage. Two months after the release, palms were carefully dissected and checked for the presence of *R. ferrugineus* and all specimens found, either dead or alive, were counted. To evaluate product persistence the same procedure was repeated on a monthly basis for up to 6 mo from treatment.

Curative Assays. Twenty four palms were infested with 3-d-old larvae of *R. ferrugineus.* Sixteen holes 3 cm in depth and 1 cm in diameter were drilled around the trunk of each palm. Subsequently, one single 3-d-old larvae was introduced into each hole. Two days later, three palms were painted as described above. Three additional groups of three palms each were painted at weekly intervals for up to three more weeks. One month after the painting, the corresponding three treated palms plus three control plants were carefully dissected and processed as described above.

Data Analysis. Laboratory results (fecundity of adults and egg hatching) were subjected to one-way analysis of variance (ANOVA). Semifield results (percentage of mortality and number of immature stages found alive) were subjected to a two-way-ANOVA. The two factors were time and treatment. Before analysis, percentage mortality and number of immature stages were subjected to the angular and logarithmic transformation, respectively. The efficacy of treatments was evaluated according to Abbott (1925) for the number of immature stages of *R. ferrugineus* found alive per palm. Efficacy of the preventative treatment was subjected to one-way ANOVA. When necessary, the least significant difference (LSD) test was used for mean separation ($P < 0.05$).

Results

Table 1 shows the effects of the different formulations tested on mortality of adults and the reproductive parameters of *R. ferrugineus.* At the first sampling date (2 d), all adults in contact with chlorpyrifos (paints 2 and 4) were found dead, whereas survival of adults exposed to the remaining formulations (control, paint 1 and 3) was complete. Eighteen days later, adult mortality in these formulations ranged from 5 to 20%. No significant differences were observed in the reproductive parameters (fecundity and egg hatching) of adults exposed to these formulations.

Table 2. Effect (mean ± SEM) of Inesfly IGR FITO on the immature stages of *R. ferrugineus* in the laboratory

	Eggs (n = 4)		Survival (%) 15-d-old larvae (n = 10)		Survival (%) 60-d-old larvae (n = 10)	
	Egg hatching (%)	Neonate survival (%)	24 h	Next instar	24 h	Next instar
Control	78.8 ± 4.9a	55.6 ± 0.9	98.0 ± 2.1	100	100	100
Inesfly IGR FITO	51.3 ± 7.9b	0	0		0	

Within a column, means followed by the same letter are not significantly different from each other ($P < 0.05$; LSD test).

Inesfly IGR FITO caused 100% mortality in all immature stages of *R. ferrugineus* tested (Table 2). Hatching of eggs deposited on the painted surface was significantly lower than that of control eggs ($F = 11.52$; df = 1, 6; $P = 0.0146$). Further development on treated surfaces was not possible and neonate larvae died soon after hatching. Similarly, both 15- and 60-d-old larvae exposed to Inesfly IGR FITO suffered complete mortality before reaching the next stage.

In the preventative assay (Table 3), infestation fluctuated along time. Both the application of Inesfly IGR FITO and the timing of its application significantly affected the number of immature stages found alive in the palms (Table 3), but the interaction between these factors was not significant. Females of *R. ferrugineus* released for oviposition were able to cause infestation in 90.5% of the control palms. On the contrary, the Inesfly IGR FITO treatment prevented infestation in 47.6% of the palms. Control palms had significantly higher numbers of immature stages than treated palms (mean of 22.8 ± 5.0 versus 3.9 ± 1.5 immature stages per palm, $P < 0.0001$; Table 3). There were no significant differences in efficacy values obtained during the 6 mo considered (mean of 83.3 ± 5.3%; Table 3).

Neither the treatment nor the time between infestation and product application significantly ($P < 0.05$) affected *R. ferrugineus* mortality when Inesfly IGR FITO was applied as a curative treatment in semifield assays (Table 4). Therefore, its efficacy was null.

Discussion

The present work demonstrates that Inesfly IGR FITO can effectively control eggs, larvae, and adults of *R. ferrugineus* when insects come in contact with the product. Laboratory results obtained with the paint without chlorpyrifos prove that this active ingredient is the cause of the efficacy of the product. Similar results (mean time of mortality <24 h) were obtained in laboratory assays with chlorpyrifos applied on *Rhynchophorus cruentatus* (F.) adults (Giblin-Davis and Howard 1989). The 0.063% pyriproxyfen, which is included in this formulation, did not significantly affect either survival or reproduction of *R. ferrugineus.* This active ingredient could be useful to complement chlorpyrifos to control pests such as aphids and ants in other crops (e.g., citrus and vegetable crops) (Kerns and Stewart 2000, Liu and Chen 2001, Stanley 2004, Richardson and Lagos 2007), but it seems unnecessary for the specific purpose of controlling *R. ferrugineus.* However, our assay lasted for 20 d and its effects on *R. ferrugineus* could occur later or affect the F_1. Chlorpyrifos is widespread used to control insect pests. It is authorized in Spain (MARM 2009) against different pests (Lepidoptera, Orthoptera, Hemiptera, and Coleoptera), including a few Curculionidae [*Curculio nucum* L. in hazelnut and *Cosmopolites sordidus* (Germar) in banana]. It is recommended to control *R. ferrugineus* in several countries within the European

Table 3. Mean number of immature stages of *R. ferrugineus* found in *P. canariensis* per month as a function of the time elapsed since Inesfly IGR FITO application and efficacy of each treatment (n is three palms per treatment and time) in semifield tests

Time (d) after treatment application	Infested palms (%)		Mean no. immature stages alive (±SEM)[a]			Efficacy (± SEM) (%)
	Control	Inesfly IGR FITO	Control	Inesfly IGR FITO	Grand mean[b]	
4	100	66.7	30.67 ± 28.43	2.33 ± 2.27	16.50 ± 13.35abc	92.4 ± 7.4
30	100	66.7	45.33 ± 7.62	12.33 ± 10.59	28.83 ± 9.62a	72.8 ± 23.4
60	100	100	16.67 ± 6.09	3.33 ± 1.78	10.00 ± 4.14abc	79.0 ± 10.7
90	100	0	13.33 ± 5.30	0	6.67 ± 3.89bc	100
120	66.7	33.3	12.67 ± 13.72	2.33 ± 2.86	7.50 ± 6.15c	81.6 ± 22.6
150	100	66.7	37.00 ± 22.23	6.0 ± 3.94	21.50 ± 11.80ab	83.8 ± 10.6
180	66.7	33.3	3.66 ± 2.86	1.0 ± 1.22	2.33 ± 1.4c	72.73 ± 33.4
	Source of variation					
	Treatment		Time		Interaction	
ANOVA	$F = 25.24$; df = 1, 28; $P < 0.0001$		$F = 2.85$; df = 6, 28; $P = 0.0270$		$F = 0.54$; df = 6, 28; $P = 0.7734$	$F = 0.43$; df = 6, 20; $P = 0.8497$

Palms were infested with three mated females each and dissection took place 1 mo after infestation. The number of immature stages found alive and percentage of efficacy were subjected to a two-way-analysis and one-way analysis of variance, respectively.

[a] Data subjected to the log (x + 1) transformation before analysis.

[b] Treatment dates (time) showing the same letters are not significantly different from each other ($P < 0.05$; LSD test).

Table 4. Mean number of immature stages of *R. ferrugineus* found in *P. canariensis* and mortality 1 mo after Inesfly IGR FITO application (300 ml per palm) when applied 2, 9, 16, and 23 d after infestation with 16 3-d-old larvae, of each treatment (*n* is three palms per treatment and time) in semifield tests

Time (d) after infestation	Mean no. immature stages alive[a] (± SEM)		Mortality (%) (±SEM)	
	Inesfly IGR FITO	Control	Inesfly IGR FITO	Control
2	8.3 ± 1.6	6.7 ± 0.4	58.3 ± 2.5	47.9 ± 10.2
9	8.3 ± 1.5	9.0 ± 0.7	43.7 ± 4.4	47.9 ± 9.2
16	5.3 ± 2.5	10.0 ± 3.1	37.5 ± 19.3	66.7 ± 15.5
23	8.0 ± 0.7	6.3 ± 2.2	60.4 ± 13.5	50.0 ± 4.4

	Source of variation		
	Treatment	Time	Interaction
ANOVA	$F = 0.01$; df = 1, 23; $P = 0.9309$	$F = 1.39$; df = 3, 23; $P = 0.2826$	$F = 0.05$; df = 3, 23; $P = 0.9833$

Percentage of mortality data were subjected to a two-way ANOVA.
[a] Data subjected to the angular transformation before analysis.

Union, such as Italy and Cyprus (DGSAN 2009; MARNE 2009). However, it is not currently authorized in Spain to control pests on ornamental crops, such as *Phoenix* spp. Therefore, it could be an interesting option against *R. ferrugineus* in palms.

In the preventative assays, there were significant differences in palm infestation along time, but the interaction of time and treatment was not significant (Table 3). They were probably caused by the environmental conditions (temperature and humidity) prevailing during the infestation that are known to affect oviposition and larval development (our unpublished data). Indeed, females released in coincidence with temperatures either above 38°C (120-d assay) or below 14°C (180-d assay) resulted in significantly lower infestation that those released at temperatures in between these limits (e.g., 30- and 150-d assays) (Table 3).

Curative application of Inesfly IGR FITO on infested palms was not effective against *R. ferrugineus*, probably because active ingredients were unable to reach the insects inside the palm. This is the main handicap found when trying to control *R. ferrugineus* in infested palms because the target pest is protected for the whole cycle of development inside the palm. This is the reason why systemic insecticides, such as imidacloprid (Kaakeh 2006), or products including biological control agents, such as *Steinernema carpocapsae* (Weiser) (Nematoda: Steinernematidae), which can actively search and infect the pest (Llácer et al. 2009), are the only curative products with proven effectiveness against this pest (Dembilio et al. 2009b). Mortality of the introduced larvae used in this assay was 48.4% ± 3.3 (mean of the both treated and control palms; $n = 24$), and this should be attributed to natural mortality factors acting on the immature stages of *R. ferrugineus.* In a similar set of assays (Dembilio et al. 2009a), natural mortality in *P. canariensis* was 51.7 ± 4.8%.

Efficacies obtained in preventative assays 4 and 30 d after Inesfly IGR FITO application (92.4 ± 7.4 and 79.0 ± 10.7%, respectively) were very similar to those obtained when using *S. carpocapsae* in a chitosan formulation (Biorend R Palmeras) (93.5 ± 7.5 and 75.7 ± 8.1% for 4 and 30 d, respectively) (Llácer et al. 2009).

Prophylactic measures against red palm weevil generally involve insecticide use in different methods (e.g., protecting wounds, frond axil filling, spraying or soaking palms, dipping offshots, and soil application) to protect palms so that the ideal sites for oviposition are not available to the weevil. Inesfly IGR FITO application could reach these places without having to be applied frequently. This insecticide was effective for at least 6 mo, but its persistence could be longer. We did not test longer periods because low temperatures limit natural infestation by *R. ferrugineus* in palms in temperate countries. This microencapsulated formulation, compared with other formulations with chlorpyrifos, confers the advantage its long duration (López et al. 1999, Mosqueira et al. 2005, Días and Jemmio 2008, Amelotti et al. 2009). Furthermore, the product presents good handling characteristics and confers a good appearance to treated surfaces. Different methods (e.g., paintbrush, aerosol, and airless spray) to apply Inesfly IGR FITO are currently being tested to compare efficacy, persistence, safety, and facility to use (E.L. and J.A.J., unpublished results). It is necessary to emphasize that a careful application of the paint is very important to prevent oviposition because several new infestations observed in painted palms started in underground areas of the stipe where no paint had been applied. When used in palms, new grown or recently pruned areas should be painted.

Preventative treatments are very important to control other palm pests with similar life histories in palm oil, coconut, and dates as well as ornamental palms, such as *Rhynchophorus* spp., *Diocalandra frumenti* (F.) (Coleoptera: Curculionidae), or *Metamasius hemipterus* L. (Coleoptera: Curculionidae). This kind of treatments can save palms from damage associated with injury and control pests before they are protected by palm tissues. Because the results obtained in the preventative assay prove that Inesfly IGR FITO can prevent infestation for at least 6 mo without losing its efficacy, two applications per year, before the main

flight periods observed in the northern Mediterranean Basin (April and September) carefully covering oviposition sites, could prove effective to protect palms from *R. ferrugineus* infestation. Currently a field assay where Inesfly IGR FITO is applied and compared with other chemical products is in progress in a *R. ferrugineus*-infested area. The impact of environmental factors (e.g., sunshine, rain, and wind) on the efficacy of this product against *R. ferrugineus* need to be assessed.

Acknowledgments

We thank J.E. Peña (Tropical Research and Education Center, University of Florida, Homestead, FL) for critically reviewing an earlier version of this paper; L. Bellver (IVIA) for valuable help during the assays; the palm nurserymen association ASFPLANT for providing the palms used in these assays; and Industrias Químicas Inesba S.L. for the insecticidal paints used in this study. This research was partly funded by the Spanish Ministry of Science and Innovation (MCINN project TRT2006-00016-C07-01) and the Valencian Department of Agriculture, Fisheries and Food (CAPA, project IVIA-5611). E.L. was recipient of a postdoctoral fellowship from the MCINN (Juan de la Cierva program, cofunded by the European Social Fund), Ó.D. was recipient of a predoctoral grant from IVIA.

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Received 15 September 2009; accepted 25 November 2009.