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Recognition, handling and inspection protocol for *Diocalandra frumenti* (Fabricius) on Canary Island Palm Trees

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Technical Manual No.1
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Recognition, handling and inspection protocol for *Diocalandra frumenti* (Fabricius) on Canary Island Palm Trees

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1. Introduction

The four-spotted coconut palm weevil, *Diocalandra frumenti* (Fabricius) (Coleoptera: Dryophthoridae), is native to Southeast Asia. It is also widespread in the tropics and in various coastal areas of the Pacific and Indian Oceans.

This insect has been detected in at least 17 genera of the Arecaceae family, most of which are economically important palm species, cultivated for their food or ornamental interest. Its main hosts are the coconut palm (Cocos nucifera L.), the Canary Island palm (*Phoenix canariensis* H. Wildpret) and its hybrids. Other minor hosts are the date palm (*Phoenix dactylifera* L.), oil palm (*Elaeis guineensis* Jacq.), *Washingtonia* spp., nipa (*Nypa fruticans* Wurmb) and many other ornamental palms. The complete list is available at https://gd.eppo.int/taxon/DIOCFR/hosts.

2. *Diocalandra frumenti* (Fabricius) as a pest

2.1 Identification

The genus *Diocalandra* comprises 15 species, of which *D. taitensis* is closely related to *D. frumenti*.

Adults of *D. frumenti* are small (6-8 mm long) with elongated-bodies and bright yellow-brown when newly emerged, turning reddish-brown or black as they mature. They have black markings on the pronotum and elytra, and four yellowish-brown spots on the elytra.

By contrast, adults of *D. taitensis* have reddish-yellow legs and markings on the thorax and elytra, varying from almost red to red with six black dots or markings, two median-basal and two apical.

The pygidium of *D. frumenti* females is ferruginous to black, with centrally arranged erect setae and a dense row of erect setae on the apical margin. Whereas in *D. taitensis*, the erect setae are arranged on the apical margin and form a central ridge (Figure 1).

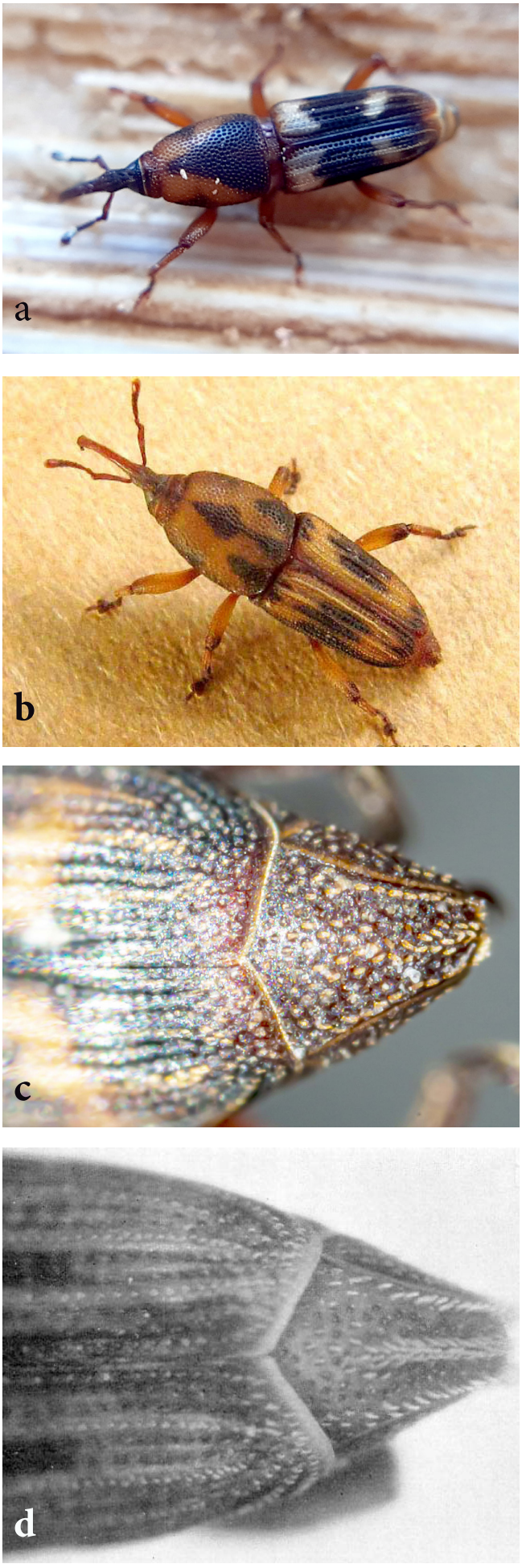


Figure 1. Dorsal view of a) *D. frumenti* and b) *D. taitensis* and, arrangement of the setae on the pygidium of a female of c) *D. frumenti* and d) *D. taitensis*

Adults of *D. frumenti* show morphological variations in size, colour and mottling, which may be due to microclimatic conditions, food availability and the maturity of the host plant on which the individual is feeding (Figure 2).

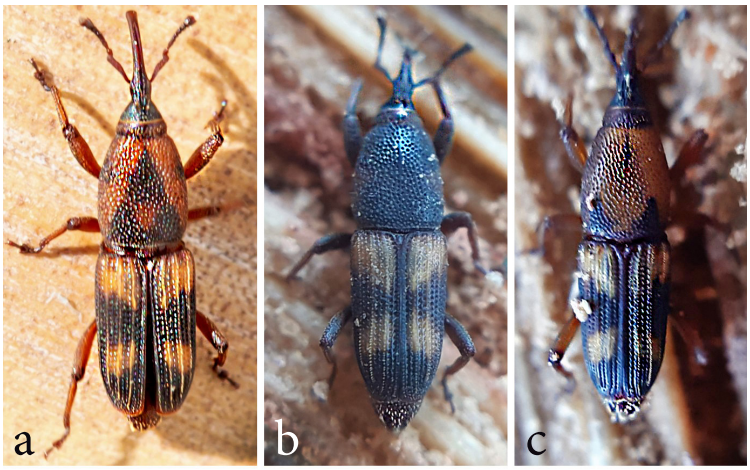


Figure 2. Dorsal view of *D. frumenti* showing different colouration patterns on the head, pronotum and elytra.

2.2 Description and biology

Diocalandra frumenti has four developmental stages: egg, larva, pupa and adult. The incubation period of the eggs lasts 4 to 9 days. Larval development lasts 8 to 10 weeks, and pupal development is between 10 and 12 weeks. The complete life cycle takes 10 to 12 weeks.

The egg of *D. frumenti* is white, oval, approximately 0.9 mm long by 0.3 mm wide. The female *D. frumenti* lays her eggs in a scattered pattern at a depth of 1 to 2 mm in the young tissues of palm trees.

The first larval stage is translucent white with a yellow-brown, shiny, sclerotised head. The body colour turns yellow as it matures. The larva is rough, segmented, eruciform and apodous, moving by rhythmic contractions of the thoracic segments. The body length of a mature larva ranges from 2 to 8 mm.

The pupa is adectic and exarate, with wings and appendages free, visible and clearly separated from the body. The average length is between 5 and 7 mm.

Females have larger average sizes than males. The sexes can be easily separated based on rostral characters. The female's rostrum is thinner, shiny and apically arched, while the male's rostrum is broader, rough in texture, with prominent pits and apically uncurved.

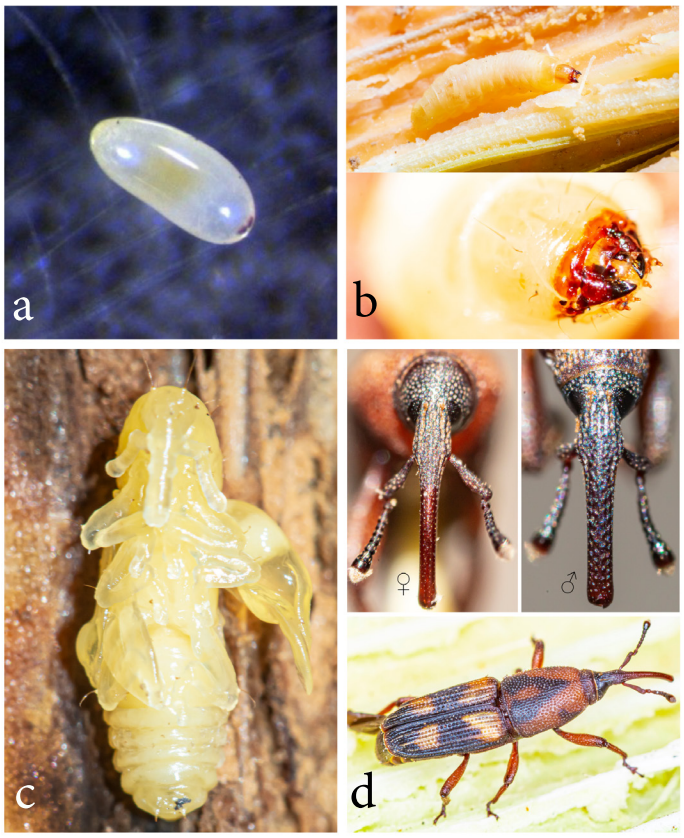


Figure 3. *D. frumenti* stages: a) egg, b) larva and detail of the powerful mandible, c) pupa and d) adults and detail of sexual differentiation based on the rostrum.

2.3 Location of *D. frumenti* on the palm tree

Adults of *D. frumenti* may be attracted to a palm tree by sap exuding from a wound or from the base of flowers. Cuts made in the leaves during pruning, or leaf tearing caused by strong winds, are the areas initially attacked by *D. frumenti*.

Females may lay their eggs in the interstices, inflorescences, at the base of petioles or peduncles, or in crevices near adventitious roots at the base of the stipe. When the larvae hatch, they burrow into any part of the palm: roots, petioles, inflorescences, leaves, leaf sheaths, fruit and at any height of the stipe, feeding on the young tissue through which the sap circulates to the palm's leaflets. They develop entirely inside the palm tree.

Pupation takes place in tunnels excavated by the larva, without the formation of a cocoon. The pupal chamber is formed near the epidermis and forms a circular hole of 1.5 mm in diameter through which the adult emerges. To emerge, the adult uses its rostrum to remove debris from the gallery.

2.4 Incidents and damage to the palm tree

When the larvae excavate galleries 1 to 2 mm in diameter in healthy tissues in the basal third of the rachis of green leaves, they produce gummy exudations that can cause premature drying and collapse of the palm crown leaves, starting from the outer to the inner leaves. The larvae pierce the rachis of the palm leaf distally, starting from the petiole. In severe attacks, the palm may even die.

Indirect damage attributed to *D. frumenti* is that of acting as a vector in the spread of fungal diseases caused by opportunistic fungi, such as *Nalanthamala* (=*Gliocladium*) *vermoesenii* (Biourge) Schroers, or constituting the entry route for phytopathogenic fungi lethal to the palm tree such as Ceratocystis *paradoxa* (Dade) C. Moreau, *Fusarium oxysporum* f. sp. canariensis Mercier & Louvet or *Thielaviopsis radicicola* (Bliss), Z.W. De Beer & W.C. Allen (previously identified as *Thielaviopsis punctulata*).

2.5 Dispersion modes

There are no data on the natural dispersal of *D. frumenti*, although it is known that adults can move short distances and that the movement of infested palms contributes to the dispersal of the pest over long distances. This is particularly important in nurseries.

There is a potential risk of *D. frumenti* spreading from its current range to other regions where palm trees are cultivated, because the climatic conditions are moderately similar, according to the Köppen-Geiger climate classification. According to this classification, several regions represent climatic categories suitable for the development of the species.

3. Control measures

3.1 Preventive or cultural control

These procedures can be varied and are intended to prevent or reduce the incidence of *D. frumenti* on palm trees:

- Avoid drastic pruning of green leaves as far as possible. Only dry basal leaves should be removed.
- Brushing of the stipes of palm trees should not be allowed, as the bases of the rachis of palm leaves maintain the activity of their tissues for a long time. Brushing using cutting tools facilitates the entry of opportunistic pathogens and favours the attraction of adult *D. frumenti* to the trees due to the kairomones emitted by the plants when wounded.
- Cleaning of stipes (removal of leaf blades without the use of cutting tools) may be carried out but should always be accompanied by treatment with an authorised fungicide and insecticide.
- Cover any cut surfaces with acrylic paint or healing paste to prevent adult *D. frumenti* being attracted to the kairomones emitted by the plants when a wound occurs.
- Cover adventitious roots at the base of the stipe with soil to prevent oviposition of *D. frumenti* females.
- Use the proper tools for climbing and pruning palm trees with the aim of minimizing the damage to the palm trees. These tools must be properly disinfected to avoid the spread of spores of phytopathogenic fungi.
- Properly manage pruning waste from palms affected by *D. frumenti* by collecting the material and depositing it in landfills, thus avoiding possible sources of dispersal. Pruning waste infested with *D. frumenti* must be transported to landfills in lorries covered with tarpaulins or other suitable covers to prevent the spread of the pest.
- Transplanting palm trees located in areas where *D. frumenti* is present should be avoided so as not to encourage the spread of the pest. If for any reason palm trees must be moved, a systemic treatment via irrigation or endotherapy, or a foliar spray treatment, should be applied to ensure that the palm is free of the pest. These tasks must be supervised by a technician appointed by the competent body.
- Plants infested with *D. frumenti* should not be sold in palm nurseries. Palm trees showing a

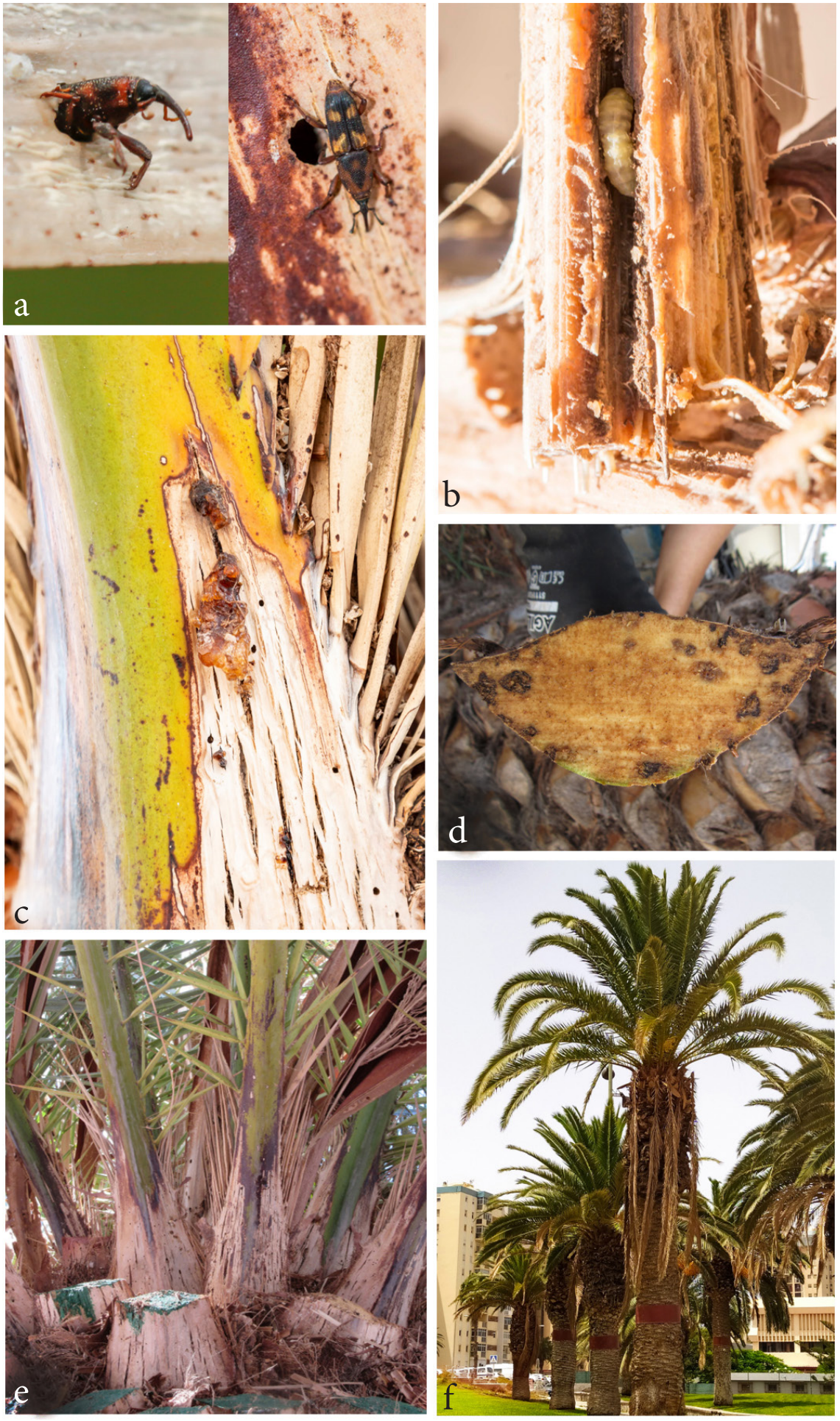


Figure 4. Direct damage by *D. frumenti* on palm trees: a) exit holes, b) detail of the sawdust generated by a larva in a longitudinal gallery in the rachis of a leaf, c) presence of gummy exudates at the entrance of the galleries, d) galleries in a cross section of the rachis of a leaf, e) lateral drying at the base of the leaves and g) collapse of the basal rings of leaves, of the palm tree.

high level of infestation must be destroyed. All plants present in the nursery, as well as new entries, must be inspected regularly for signs of infestation. Strict quarantine must be maintained in the nursery.

3.2 Biological control

Natural enemies

Studies on the natural enemies of *D. frumenti* and other species of the genus are scarce. The following are cited in the literature: *Anoplolepis custodiens* Smith and *Oecophylla smaragdina* L. (Hymenoptera: Formicidae) (Vanderplank, 1953), *Spathius apicalis* Westwood (Hymenoptera: Braconidae) (Lever, 1969), *Plaesius javanus* Erichson (Coleoptera: Histeridae) and *Chrysophilus ferruginosus* Wiedemann (Diptera: Rhagionidae).

Entomopathogenic fungi

- *Beauveria bassiana* (Bals.) Vuill. (Hypocreales: Cordicipitaceae): at laboratory level, the mortality percentages recorded for Naturalis® and Velifer® (75%), followed by Ostrinil® (65%) and Serenisim® (55%) stand out, with Phoemyc+® being the product that showed the lowest mortality of *B. bassiana* (35%). Available at: https://indd.adobe.com/view/b9984ca9-2a70-4c72-87b0-d045caeff880.

- *Metharhizium anisopliae* (Metschnikoff) Sorokin (Ascomycota: Hypocreales): percentages of adult mortality achieved in the laboratory (68-91.1%) and at semi-field level (89.6-100%) 15 days after treatment are noteworthy. At field level, 65 days after treatment, the percentages of infested fruit and bunches in treated palm trees were 10.5% and 12.4%, respectively, compared to the percentages recorded in control palm trees (45.6% and 35.8%).

Entomopathogenic nematodes

The effectiveness of the entomopathogenic nematode *Steinernema feltiae* Filipjev (*Rhabditida: Steinernematidae*) in the control of *D. frumenti* was remarkable, with adult mortality rates of 53.3% and larval mortality rates of 75.05%. The larval stage is the most susceptible to attack by entomopathogenic nematodes.

3.3 Biotechnological control

The trapping system to carry out detection, monitoring and/or control of *D. frumenti* includes the following components:

Trap

The Palm Rocket Tramp® (Ecobertura®, https://ecobertura.es/) has been specifically designed for catching *D. frumenti* and is marketed under the reference number 062-TD. The trap consists of three sections: an upper section or dome with an inner housing for the pheromonal attractant, a middle section with a housing for the kairomonal attractant and a flap drive mechanism that allows stable anchoring in the palm tree, and a basal body with a capacity of 1 litre.

Figure 5. Palm Rocket Trap®.

Attractants

The pheromone attractant of *D. frumenti* is emitted by the males of the species and attracts both sexes, making it a very suitable tool for mass trapping. The pheromone of *D. frumenti* is registered in the Register of plant protection products of the Ministry of Agriculture, Fisheries and Food, under the trade name ZENTINEL® DF (Ecología y Protección Agrícola, S.L., https://www.epa- ecologia.com/)

and dossier number 084/2019. These are rubber septa type diffusers, with an approximate shelf life of 30 days depending on environmental conditions, packaged in individual sachets, which can be kept refrigerated for two years.

As for the kairomonal attractants, a mixture of ethyl acetate (Sigma-Aldrich®) and ethanol (Merck Millipore®) in a 3:1 ratio is used, priming the trap with 60 ml of the mixture placed in a polypropylene jar with a hole in the lid to facilitate the diffusion of the volatiles.

Retentive

The Palm Rocket Tramp® by design does not require internal impregnation with insecticide.

Moisture supply

One litre of hydrogel (Ecobertura®, https://ecobertura.es/) (a hydrophilic polymer which increases considerably in volume in the presence of water and releases the water required in the trap in a controlled manner) is placed in the basal body of the trap. This hydrogel also has a retentive effect on insects caught in the trap, so it is not necessary to impregnate the trap with an insecticide

Anchoring the trap to the palm tree

The trap is placed between the first and second green leaf ring of the flange by means of a telescopic pole.

Review of the trap

The service life of the trap is two months. After this time, the trap should be checked to replace the pheromone septum and to replenish kairomone and hydrogel levels in the trap. It is advisable to wear gloves when handling the pheromone dispensers to prevent the oils on our skin from clogging the pores of the rubber and reducing the release of the attractant.

Counting the adults captured helps determine the population dynamics of the pest in the area and to check the effectiveness of control measures on the pest.

3.4 Chemical control

Within the IPM approach, trunk injection or endotherapy is a pesticide application technique that provides an alternative to foliar spraying or soil irrigation.

The active material emamectin benzoate 9.5% [AL] W/V (Revive II®, Syngenta España S.A.,https://www.syngenta.es/productos/proteccion-de-cultivos/insecticidas/revive-ii) has shown high efficacy in controlling *D. frumenti*, with a persistence of 2 years in palm trees, keeping the treated trees free from the pest during that time. Abamectin1.8%EC] W/V (Vertimec®,Syngenta SpainS.A., https://www.syngenta.es/productos/proteccion-de-cultivos/insecticidas/vertimec) also has a high efficacy in controlling *D. frumenti*, with a persistence in the palm tree of more than an year. Acetamiprid 20% [SP] W/W (Epik®, Sipcam Iberia, S.L., https://sipcamiberia.es/es/productos/insecticidasacaricidas/epik.html) has a low efficacy in controlling *D. frumenti*, with low persistence in palm trees and with recurrences of captures after completing the treatment, which forces repeated treatments to be carried out. Available: https://gmrcanarias.com/wp-content/uploads/2024/01/informe- Num1_endoterapia_web_pags.pdf.

Figure 6. Detail of the adults retained in the hydrogel and hanging of the Palm Rocket Trap® by means of a telescopic pole.

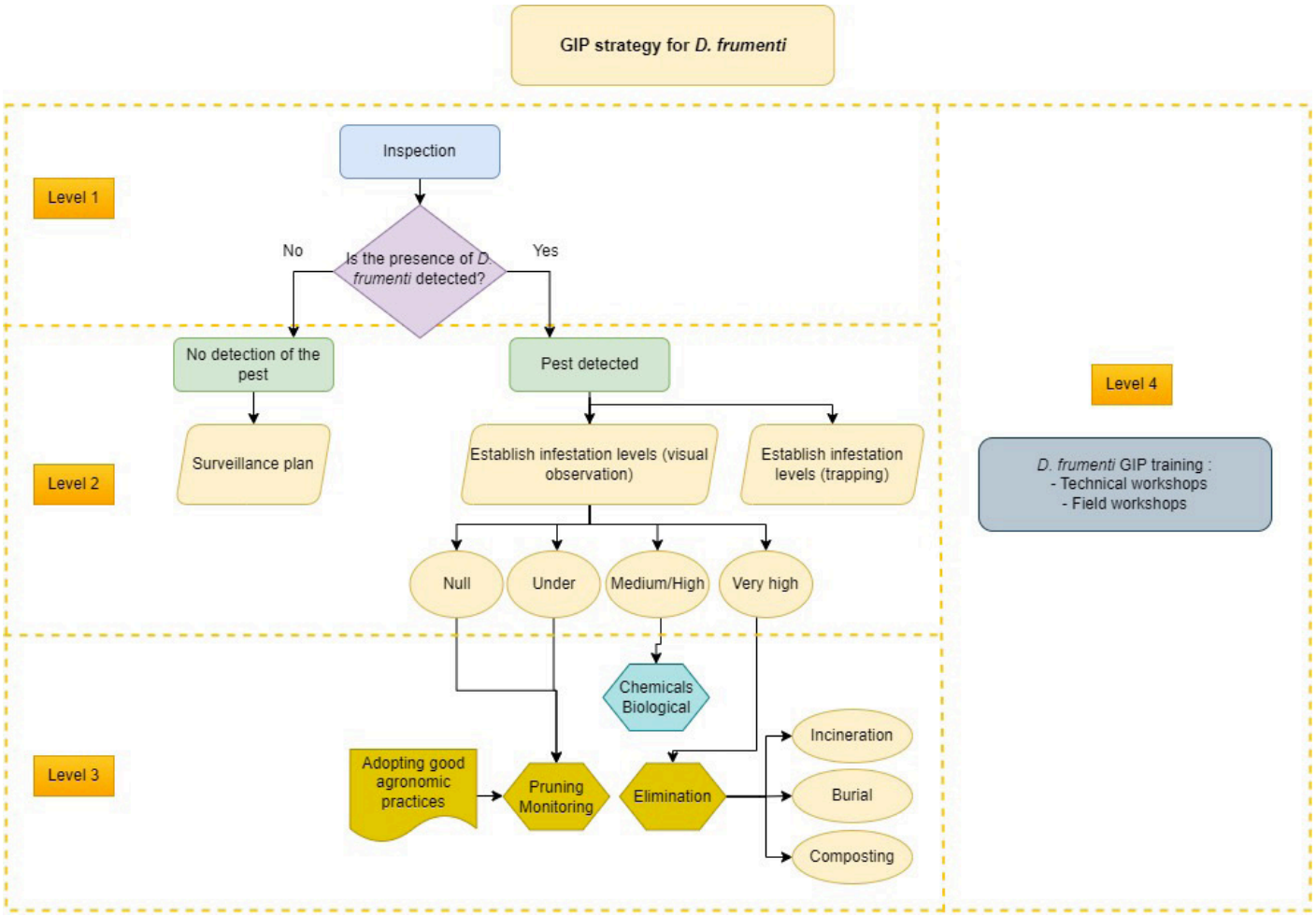


Figure 4. IPM strategy for *D. frumenti* (Source: Own elaboration).

4. Inspection protocol for *D. frumenti* in Canary Island palms

4.1 Places to inspect

Surveys should be based on the observation of symptoms of *D. frumenti* infestation, focusing on sites with a high risk of pest introduction (new palm tree plantations, recent transplantations, nurseries, landfills).

To verify and ensure that an area is free of *D. frumenti*, monitoring should be carried out on an annual basis, using semi-chemical baited traps, especially in regions with favourable conditions for establishment.

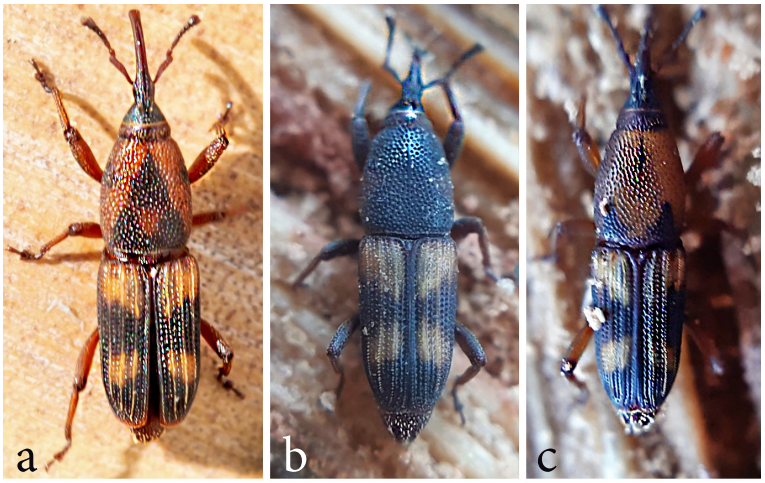
4.2 Time of inspections

The time for field surveys is in spring-summer, from April to October, as this is when adult activity occurs. There are several peaks in the population from mid-June to the end of September, within this range would be the optimal time for sampling adults.

4.3 Inspection procedure

4.3.1 Adult recognition

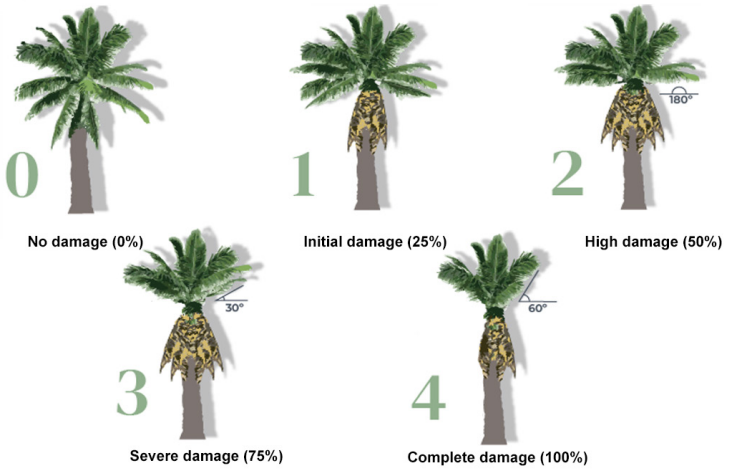
Diagnostic characteristics of *D. frumenti* are 6-8 mm in size, elongate body, bright yellowish-brown when newly emerged, turning reddish-brown or black as they mature, with four yellowish-brown spots on the elytra. Adults may vary morphologically in size, colour and maculation.



4.3.2 Recognition of damage

Detection of this weevil is difficult due to its small size and the habits of the species, so the best way to detect its presence is by recognising the damage it causes on the palm tree, as detailed in section 2.4 of this document.

The following visual scale can be used to quantify the percentage of leaves affected by *D. frumenti*. This tool can support decision-making in the application of chemical treatments:



4.3.3 Sample collection

When damage is observed or the presence of adults or larvae of *D. frumenti* is detected, several samples should be collected and sent to the diagnostic laboratory for correct identification.

Samples should be sent to the laboratory in an airtight container as soon as possible. If this is not possible, and shipment is delayed or the arthropod is not alive, adults should be shipped dry, protected with cotton wool to avoid breakage of legs and antennae. If larvae of *D. frumenti* are collected, they should be placed in an airtight container in 70% alcohol for preservation.

4.3.4 Assembly of the trap

The trap is composed of three sections: (1) dome, with housing for the pheromone, (2) middle body, with support to hold the kairomone canister and (3) basal body in which the litre of hydrogel is dispensed.

Trap Attractants Moisture supply

The Palm Rocket Trap® is hung and unhung using a telescopic pole. The trap should be placed between the first and second green leaf ring of the palm flange.

The trap should be serviced two months after field installation, replacing the pheromone septum and replenishing the levels of kairomone and hydrogel in the trap. The use of gloves is recommended

Figure 6. Detail of the adults retained in the hydrogel and hanging of the Palm Rocket Trap® by means of a telescopic pole.

4.3.5 Trap density

- In mass trapping: a trap should be placed in the palm flange on one third of the number of palm trees present in the infested area, rotating the traps to cover as large an area as possible and thus reduce the population of *D. frumenti*.

- Monitoring: Risk points need to be established and three traps should be placed in a protective belt to detect the possible entry of *D. frumenti* into the area.

4.4 Procedure after the first outbreak

After the first outbreak of *D. frumenti*, the following steps are recommended:

- Delimitation of the demarcated area by counting and inspection of all the palm trees in the area.
- Search for the source of the outbreak by inspecting new palm plantations, recent transplantations, nurseries and landfills.
- Correct management of affected palm trees by sanitising or eliminating the palm tree, implementing a trapping system or establishing a treatment schedule.
- Carry out an information and awareness campaign for operators involved in the area.

4.5 Notification of pest outbreaks

La notificación de la presencia o sospecha de la plaga deberá comunicarse inmediatamente a la autoridad competente en materia de sanidad vegetal.

4.6 Bibliografía

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