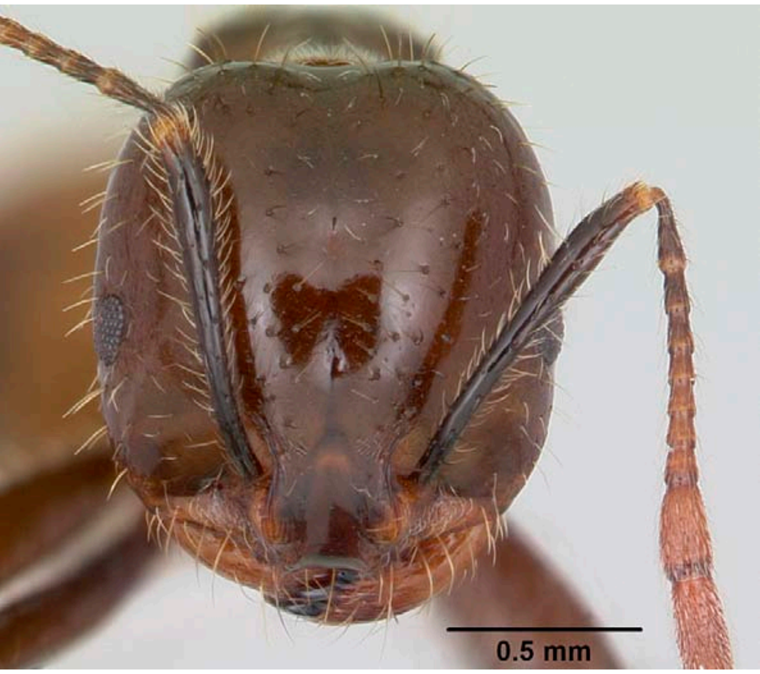

Head view of Solenopsis richteri. *© April Noble.*

The management of the black imported fire ant (*Solenopsis richteri*)

Measures and associated costs

Scientific name(s)	*Solenopsis richteri*
Common names (in English)	Black imported fire ant
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Summary of the measures, emphasizing the most cost-effective options.

To reduce the chances of establishment of exotic ants in Europe, it is necessary to prevent their accidental entry. Quarantine inspections and treatments methods used in USA and China could be used in Europe. To do this, Europe needs to officially consider invasive ants as quarantine pests. The problem caused by invasive species should not exclusively be the concern of countries of entry, but rather should be treated in collaboration to reduce risks of goods contamination. To increase efficiency in methods to achieve prevention, a careful inspection of goods at port-of-exit should be associated with active prevention at ports-of-entry. A careful inspection of the goods before shipment will decrease species dispersion and risks of invasion.

A successful eradication programme is inseparable from an early detection of the infestation. Therefore, it is essential to develop contingency plans against this and other invasive ants at a European scale to be ready when ants are detected. European members should establish a list of ant specialists to whom the samples can be sent for rapid identification.

There is probably no single method that will allow, alone, the control of *S. richteri* if this latter is introduced in Europe. However, currently the most effective control methods use chemical insecticides. Eradication of single nests in buildings, contained environments and containers is fairly straightforward and can be achieved at low cost. In areas where the climate is suitable for outdoor survival, efforts should be made to eradicate the nest(s) before queen's escape into the wild. If *S. richteri* is already established and has begun to spread when first detected, management plans that consist of several applications of chemical insecticides per year over three to four consecutive years, followed by at least two years of intensive surveillance have to be adopted. Countries should have lists of chemical and biochemical insecticides authorised against invasive ants (as bait or contact) ready for use in case an invasion is detected. Chemical control is best when integrated into an IPM system that will reduce the volume needed. Research on biological control should be develop and may constitute a good complement to chemical control.

The management of invasive ants and particularly of *S. richteri* suffers from a lack of operational management experience. This lack of experience with this species increases the uncertainty when defining the most cost-effective measures.

Measures for preventing the species being introduced, intentionally and unintentionally.

This section assumes that the species is not currently present in a Member State, or part of a Member State's territory.

Inspection of imported goods and containers and destruction of nests and ants found at inspection.

MEASURE DESCRIPTION

Goods, in particular soil, plants, wood, food and feed material from infested regions should be inspected at ports of entry. Because such systematic inspection is impossible, the selection of goods to inspect should consider their nature but also their origin.

Introduced ants are not drawn randomly from the biogeographic regions of the world (Miravete *et al.,* 2014; Bertelsmeier *et al.,* 2018). Most species intercepted in The Netherlands for example, had a Palearctic or Neotropical origin (Miravete *et al.,* 2014). Therefore, close attention should be paid to imports coming from these regions, especially the Neotropical region where *S. richteri* is present. However, invasive ants do not only arrive from area of origin of the species but also via other localities (Bertelsmeier *et al.,* 2018) (see Wetterer, 2010 for the species introduced range). In addition, in some cases, the species travels in goods and containers that transit via non-infested regions (Ma *et al.,* (2010) in Wang *et al.,* (2013)).

To increase efficiency in methods to achieve prevention, a careful inspection of goods at port-of-exit should be associated to an active prevention at ports-of-entry.

Solenopsis richteri may not be easily recognised by inspectors but all ant species, in particular queens and nests, should be destroyed immediately.

USDA (2010) and USDA (2015) provide guidelines on how to treat infested commodities at ports of entry. This can involve immersion or dip treatment, drench treatment, topical treatment, Incorporation of granular insecticides into potting media, etc.

Besides visual inspection, baiting is a labour-efficient method of fire ant detection in China, but different techniques are required for specific goods (Hwang *et al.,* 2009; Wang *et al.,* 2013).

In addition, the use of sniffing dogs is possible and might be a labour- and cost-efficient method of fire ant detection (see Lin *et al.,* 2011).

ADDITIONAL COST INFORMATION

To reduce the chances of establishment of exotic ants in Europe, it is necessary to prevent their accidental entry. At the global scale, the number of introduced species in temperate regions is considered to be three and half times higher than the number so far detected (Miravete *et al.,* 2014), which highlights the need to set up a common detection method at ports and airports at a European scale.

Quarantine inspections and treatments methods used in the USA and China could be adopted in Europe. Similar guidelines as those from USDA (2010, 2015) should be developed for invasive ants in general. In Europe, invasive ants are not officially considered as quarantine pests and, therefore, there is no legislation that specifically obliges quarantine services to identify, destroy and notify ants intercepted at inspections. However, inspection services in Europe are insufficiently equipped to cope with the vast and increasing amount of materials imported, resulting in only a small proportion of the imported materials actually

Profile view of the black imported fire ant. © April Noble © AntWeb.org. CC BY-SA 3.0.

being inspected. An increased investment in manpower for inspection is needed, combined with a more risk-based approach to better target high risk items.

To increase the efficiency of prevention efforts, a careful inspection of goods at port-of-exit should be combined with an active prevention mechanism at ports-of-entry to prevent contamination. New Zealand is likely the most proactive jurisdiction preventing exotic species incursions; their biosecurity activities extending into four ports in three surrounding countries. This has proven to be efficient with a 98.5% reduction in contamination rates by ants of inbound goods within 12 months of active management (Nendick, 2008). This system has led to reduced biosecurity contaminant and pest levels in New Zealand; inspection actions have been reduced by 850 hours per annum, freeing staff for other vital work; significant cost reductions for importers and faster container clearance in New Zealand and less congestion in New Zealand ports as containers move off-port faster.

There is no information on the costs related to prevention methods for *S. richteri*.

LEVEL OF CONFIDENCE[1]

Medium.

1 See Appendix

Measures to achieve rapid eradication after an early detection of a new occurrence.

Mechanical control.

MEASURE DESCRIPTION

When single nests are found in a confined container, such as a flowerpot, destruction can be done manually through heat or freezing treatments (USDA, 2010, 2015).

However, to eradicate outdoor, established populations chemical insecticides are the only effective method for use.

ADDITIONAL COST INFORMATION

Mechanical control methods are clearly effective when dealing with small number of animals or individual nests but are likely to be of limited use when dealing with more widespread populations in more open environments. No data are available on costs and effectiveness of non-chemical eradication attempts.

LEVEL OF CONFIDENCE[1]

High.

Chemical control with insecticides.

MEASURE DESCRIPTION

Eradication of single nests and, in particular, multiple nests, is best achieved using insecticides.

Methods to kill single nests in containers such as potted plants, grass sod, baled hay, etc. are described in USDA (2015). They include immersion or dip treatment, drench treatment, topical treatment, and incorporation of granular insecticides into potting media. Single nests in buildings can also be destroyed using insecticide baits such as those commonly used to combat ants in buildings (Noordijk, 2010). Eradication of established population outdoors is more problematic, especially when high numbers of nests are involved. The use of broadcast granular bait-formulated products is recommended.

A list of eradication programmes carried out against *S. invicta* outdoors is provided in the GERDA database (Kean *et al.*, 2017), which also lists techniques and products used for the eradication and references. Considering the similarity (phylogeny, biology and ecology) between *S. richteri* and *S. invicta*, examples of success and failures in attempts to eradicate *S. invicta* are relevant to *S. richteri*.

ADDITIONAL COST INFORMATION

Eradication of single nests in buildings, contained environments and containers is rather straightforward and can be achieved at low cost. In areas where the climate is suitable for outdoor survival, efforts should be made to eradicate the nest(s) before queen's escape in the wild.

There is a lack of specific information on the food preferences and control of *S. richteri*. No differentiation between the two species *S. richteri* and *S. invicta* is made in USA management of fire ants. Many of the commercial ant baits are labelled for use on fire ants in general. Without experimental testing of bait preference and efficacy, the assumption is that control of *S. richteri* using toxic baits should be based on those used for effective control of *S. invicta*.

Results of outdoor eradication programmes targeting *S. invicta* have been variable (see Kean *et al.*, 2017 who describe 12 eradication programmes). The ant has been eradicated from various areas, including from climatically suitable ones (such as New Zealand and parts of Australia and Taiwan), but many eradication attempts failed (in various areas in USA, Australia and China). The eradication

1 See Appendix

plan that has been put in place in Australia in early 2000s has cost so far about AUS$300 million for treating an area of nearly 70,000 ha. It has achieved the eradication of at least two incursions, but others have not yet been eradicated, although at least one of them is now under containment (Invasive Species Council, 2015).

The primary reasons for the failure of eradication attempts in USA include: (i) the inability to attain absolute (100%) control using available products; (ii) the large area of infestation; (iii) high cost of treatment; (iv) inability to uniformly treat an entire area of infestation (Drees *et al.,* 2006); and (v) the ability of fire ants to rapidly spread even before eradication efforts are put in place (Drees *et al.,* 2013).

In Taiwan, an infestation of 13 ha with a total of 1,578 mounds was successfully eradicated within one year. However, eradication programmes that were most successful were those involving one or a small number of nests, such as the two successes achieved in New Zealand (Christian, 2009). The eradication of *S. invicta* in early 2000s in Auckland covered less than 1 ha but cost NZ$1.4 million.

In Australia, an eradication programme of *S. invicta* was evaluated at AUS$200 million (Hoffmann *et al.,* 2010). This programme had noteworthy success and highlighted valuable lessons. For example, the programme revealed clear differences in the efficacy of bait application; aerial application has proven to be the most efficient strategy followed by hand and land vehicles application methods.

A key component to the success of the eradication programme conducted in Australia was that it was adequately though modestly funded to its conclusion (approximately AUS$60,000 for 3 ha treated) with good cooperation between the numerous stakeholders within the area targeted. This is the only successful documented attempt to eradicate *S. geminata*.

It is of utmost importance to start eradication programmes as soon as possible. Therefore, it is essential to develop contingency plans against this and other invasive ants at the European scale to be ready when ant establishments are notified. These plans should include considerations on social and environmental issues related to the use of chemical controls as well as lists of products licensed for ant control indoors and outdoors.

LEVEL OF CONFIDENCE[1]

High.

1 See Appendix

Measures for the species' management.

Chemical control.

MEASURE DESCRIPTION

Chemical control will target not only the worker but also, and importantly, the queen, to kill nests. Options include broadcast granular bait-formulated products, treatment of individual ant colonies in mounds and surface or barrier treatments using contact insecticides (Drees and Gold, 2003; Drees *et al.,* 2013; CABI, 2017). Common insecticides that can be used for fire ant control in USA are provided by Drees *et al.,* (2013) and Greenberg and Kabashima (2013). Different insecticides will be used for the different options. Drees *et al.,* (2013) also discuss the limitations of chemical treatments and their integration into an IPM system. Wang *et al.,* (2013) reviews research in China on chemical and other control methods against *S. invicta*. Of interest is the effective use of bioinsecticides (such as spinosad and plant extracts) and the good results obtained using the two-steps approach, for example, first a bait is broadcasted over large areas and, then, remnants of ant mounds are treated individually with contact insecticides.

ADDITIONAL COST INFORMATION

In Europe, similar control methods could be used, provided that the insecticides are registered in the country of application. Countries should have lists of chemical and biochemical insecticides authorised against invasive ants (as bait or contact) ready for using in case an invasion is detected. Chemical control is best when integrated into an IPM system that will limit its use to the minimum.

Data on the management costs of *S. invicta* using insecticides in USA are available (Barr *et al.,* 2005). Conventional bait insecticides cost approximately US$10 per 0.4 ha for broadcast application, and with the cost of application, total treatment costs of approximately US$17 per 0.4 ha (Barr *et al.,* 2005) but treatment effects last only 3–12 months (Drees *et al.,* 2013). Mound treatments with contact insecticides are much more expensive because *S. invicta* produces on average 168 mounds/ha (Porter *et al.,* 1992). Such treatments are justifiable only in sensitive sites such as schools or sport fields (Drees *et al.,* 2013) or after baits have largely reduced populations (Wang *et al.,* 2013).

LEVEL OF CONFIDENCE[1]

High.

Cultural and sanitary methods.

MEASURE DESCRIPTION

Cultural management methods in cattle production have been developed to limit damage of *S. invicta* to livestock. For example, the use of disc-type cutters, the quick removal of hay bales from the field and the scheduling of cow fertility programmes to avoid calving during hot, dry summer months (Drees *et al.,* 2013; CABI 2017). Other approaches can be used in different environments. In particular, it has been shown that frequent disturbance of mounds causes colonies to move to less disturbed areas (Drees *et al.,* 2013). More generally, hindering favourable habitats may be considered. Disturbed areas should be allowed to regenerate after which the vegetation succession will make the site less suitable for *S. invicta* (Noordijk, 2010).

ADDITIONAL COST INFORMATION

These and other cultural and sanitary methods could be considered for use in Europe. There is no information on the cost-effectiveness of these methods.

LEVEL OF CONFIDENCE[1]

Medium.

1 See Appendix

Biological control.

MEASURE DESCRIPTION

Many natural enemies of *S. richteri* have been identified (Briano *et al.,* 2012). They occur in its native range and are believed to keep populations at lower densities than in the invaded regions. Many of them have been studied for their potential as classical biological control agents. Several parasitic flies of the genus *Pseudacteon* (Diptera: Phoridae) have been introduced and have established and spread in the USA since 1997 (Graham *et al.,* 2003; Williams *et al.,* 2003; Morrison, 2012). *Pseudacteon tricuspis* and *P. curvatus* attack the black imported fire ant where it occurs in the USA, but their impacts on colony survival remain unknown (Callcott *et al.,* 2010).

In addition, microsporidium and viruses have been studied and at least a microsporidia, *Kneallhazia solenopsae*, has been found infecting *S. invicta* and *S. richteri* established in North America (CABI, 2017).

The entomopathogenic fungus *Beauveria bassiana sensu lato* has also been applied against *S. invicta* in the field in established mounds (Bextine and Thorvilson, 2002). Whilst the efficacy of this method has been demonstrated under laboratory conditions, few studies have validated its use in the field. However, Bextine and Thorvilson (2002) conducted two field experiments, one at the mounds scale and another at a site scale (700 m^2). In both experiments they successfully inactivated up to 80% of the mounds. Similarly, Kalfe *et al.,* (2010) succeed in inactivating 70% (22 treated) of the mounds treated with *B. bassiana*. In both studies, the most efficient delivery form was the use of baits (such as fungal pellets coated with peanut oil) instead of a direct application of the fungus.

ADDITIONAL COST INFORMATION

Pseudacteon spp. and the pathogens could possibly be considered for introduction to Europe since they are specific to one or a few exotic *Solenopsis* spp. and should therefore have limited side effects on the environment, with maybe the exception of native *Solenopsis* spp. (Folgarait *et al.,* 2002; Oi and Valles, 2012). However, so far, the effect of *Pseudacteon* spp. on *S. invicta* population densities has not been demonstrated, possibly because average parasitism rate per colony is too low (Morrison and Porter, 2005; Tschinkel, 2006; Morrison, 2012).

Some data on the cost of releasing *Pseudacteon* spp. in the USA are available in Drees *et al.,* (2013) but they are not really applicable to Europe since they do not include the necessary significant pre-release investigations. The production cost of *Pseudacteon* is estimated at $1.00 per fly. Five thousand flies were released near Gainesville (Florida) in 1997. By fall of 2005, they spread to over 90,000 square kilometres (Drees *et al.,* 2013). The cost of this release was estimated at $10,000, but considering the spread of the species, treatment cost estimate dropped down to $0.0001/ha.

Classical biological control, for example, the introduction of exotic natural enemies for their permanent establishment and long-term control of a pest, is a very cost-effective method since no action is required after releases and establishment. However, the level of control that would be achieved through the release of the flies is very uncertain.

In the Southern USA, it is thought that, collectively, these natural enemies may help reducing the frequency of insecticide applications required to maintain *S. invicta* control, but are not sufficiently effective to achieve control on their own (Oi *et al.,* 2007; Drees *et al.,* 2013).

The different agents also affect the species in different ways which influences their possible effectiveness. *Pseudacteon* spp. parasitize a small percentage of workers but indirectly affect colonies by suppressing daytime foraging behaviours whereas disease organisms directly affect ants and colony health (Drees *et al.,* 2013).

LEVEL OF CONFIDENCE[1]

Medium.

1 See Appendix

Integrated pest management.

MEASURE DESCRIPTION

To keep population levels below those that cause economic, social, or ecological damage, the integration of chemical, cultural, biological and regulatory methods into an IPM system is needed (Hoffmann *et al.,* 2010). Drees *et al.,* (2013) provide the latest information on IPM methods developed against *S. invicta* in the Southern USA. IPM design considerations include management goal(s), action level(s), ant form (monogyne or polygyne), presence of nontarget ant species, size of treatment area, seasonality, implementation cost, and environmental impact are also presented. Their conclusion is that "There is no single best IPM program for imported fire ants. Programs designed and implemented using IPM concepts will vary due to multiple factors including the presence and abundance of fire ants and other ant species, together with the level and seasonality of control desired, established natural enemies in the management area, availability of registered insecticide products for the use sites involved, environmental concerns, and cost of application(s) that include time and labour. Optimally, elegant IPM programs would be target specific, threshold driven, environmentally friendly and cost-effective. With eradication unlikely to succeed in areas larger than isolated spot infestations, containment and suppression become the overriding goals. However, within such larger landscapes, maximum control is attainable using well-designed treatment programs that, where justified, periodically use selected chemical methods."

ADDITIONAL COST INFORMATION

There is probably no single method that will allow, alone, the control of *S. richteri* if this latter is introduced in Europe.

Dorsal view of ant Solenopsis richteri. *© April Noble © AntWeb.org. CC BY-SA 3.0.*

The long expertise gained in USA on the development of IPM programmes against *S. invicta*, reviewed and analysed in Drees and Gold (2003) and Drees *et al.,* (2013) will undoubtedly help developing specific programmes for Europe. Their cost is impossible to assess in the present situation.

LEVEL OF CONFIDENCE[1]

High.

1 See Appendix

Bibliography

Barr CL, Davis T, Flanders K, Smith W, Hooper-Bui L, Koehler P, Vail K, Gardner W, Drees BM, Fuchs TW (2005) Broadcast baits for fire ant control, B-6099. Texas Cooperative Extension, Texas AandM University System, College Station, TX.

Bertelsmeier C, Liebhold AM, Brockerhoff EG, Ward D, Keller L, States U, Zealand N. 2018. Recurrent bridgehead effects accelerate global alien ant spread. Proc. Natl. Acad. Sci. USA:1–6. doi:10.1073/pnas.1801990115

Bextine BR, Thorvilson HG (2004) Field applications of bait-formulated *Beauveria bassiana* alginate pellets for biological control of the red imported fire ant (Hymenoptera: Formicidae. Environmental Entomology 31:746-752.

Briano J, Calcaterra L, Varone L (2012) Fire ants (*Solenopsis* spp.) and their natural enemies in Southern South America. Psyche 2012:19pp.

CABI (2017) *Solenopsis invicta* [original text updated by D Gunawardana]. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc.

Callcott A-MA, Porter SD, Weeks RD, Graham LC, Johnson SJ, Gilbert LE (2011) Fire ant decapitating fly cooperative release programs (1994-2008): two *Pseudacteon* species, *P. tricuspis* and *P. curvatus*, rapidly expand across imported fire ant populations in the Southeastern United States. Journal of Insect Science 11:1–25.

Christian S (2009) Red imported fire ant eradicated from Napier. Biosecurity 92: 28-29.

Drees BM, Gold RE (2003) Development of integrated pest management programs for the red imported fire ant (Hymenoptera: Formicidae). Journal of Entomological Science 38: 170-180.

Drees B M, Calixto AA, Nester PR (2013) Integrated pest management concepts for red imported fire ants *Solenopsis invicta* (Hymenoptera: Formicidae). Insect Science 20: 429–438.

Estrada C, Patrock RJW, Folgarait P, Gilbert LE (2006) Host specificity of four *Pseudacteon* spp. (Diptera: Phoridae), parasitoids of fire ants in Argentine (Hymenoptera: Formicidae). Florida Entomologist 89:462–468.

Folgarait PJ, Bruzzone OA, Patrock RJ, Gilbert LE (2002) Developmental rates and host specificity for *Pseudacteon* parasitoids (Diptera: Phoridae) of fire ants (Hymenoptera: Formicidae) in Argentina. Journal of Economic Entomology 95: 1151–1158.

Graham LC, Porter SD, Pereira RM, Dorough HD, Kelley AT (2003) Field releases of the decapitating fly *Pseudacteon curvatus* (Diptera: Phoridae) for control of imported fire ants (Hymenoptera: Formicidae) in Alabama, Florida and Tennessee. Florida Entomologist 86: 334–339.

Greenberg L, Kabashima JN (2013) Red Imported Fire Ant. Integrated Pest management in and around the home. Pest Notes. University of California Publication 7487. California, USA: University of California Agriculture and Natural Resources.

Hoffmann B, O'Connor S (2004) Eradication of two exotic ants from Kakadu National Park. Ecological Management and Restoration, 5:98-105.

Hoffmann B, Abbott KL, Davis P (2010) Invasive ant management. In Lach L, Parr CL, Abbott KL. Ant Ecology. Oxford University press, 402pp.

Hwang J-S (2009) Eradication of *Solenopsis invicta* by pyriproxyfen at the Shihmen Reservoir in northern Taiwan. Insect Science 16: 493–501.

Invasive Species Council (2015) Red imported fire ant (*Solenopsis invicta*). Factsheet available at: invasives.org.au/files/2015/01/fs-red-imported-fire-ants.pdf (accessed 5 July 2017)

Kafle L, Wu W-J, Kao S-S, Shih C-J (2010) Efficacy of *Beauveria bassiana* against the red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), in Taiwan. Pest Management Science 67:1434–1438.

Kean JM, Suckling DM, Sullivan NJ, Tobin PC, Stringer LD, Smith GR, Kimber B, Lee DC, Flores Vargas R, Fletcher J, Macbeth F, McCullough DG, Herms DA *et al.* (2017) Global eradication and response database. http://b3.net.nz/gerda (accessed 5 July 2017).

Lin HM, Chi WL, Lin CC, Tseng YC, Chen WT, Kung YL, Lien YY, Chen YY (2011) Fire ant detecting canines: a complementary method in detecting red imported fire ants. Journal of Economic Entomology 104: 225–231.

Ma J, Hu XN, Wu JJ, Zhao JP, Chen NZ (2010) An analysis for the interception dynamic of *Solenopsis invicta* Buren at ports in Guangdong. Journal of Environmental Entomology 32: 122–124.

Miravete V, Roura-Pascual N, Dunn RR, Gomez C (2014) How many and which ant species are being accidentally moved around the world? Biology Letters 10:20140518

Morrison LW, Porter SD (2005) Phenology and parasitism rates in introduced populations of *Pseudacteon tricuspis*, a parasitoid of *Solenopsis invicta*. BioControl 50: 127–141.

Morrison LW (2012) Biological control of *Solenopsis* fire ants by *Pseudacteon* Parasitoids: theory and practice. Psyche. 424817. doi:10.1155/2012/424817

Nendick D (2008) Win-win from offshore container management programme. Biosecurity 84, 12.

Noordijk J (2010) A risk analysis for the fire ants in the Netherlands. Stichting European Invertebrate Survey, Leidem, the Netherlands.

Oi DH, Valles SM (2012). Host specificity testing of the *Solenopsis* fire ant (hymenoptera: formicidae) pathogen, *Kneallhazia* (= *Thelohania*) *solenopsae* (microsporidia: thelohaniidae), in Florida. Florida Entomologist 95: 509–512.

Oi DH, Williams DF, Pereira RM, Horton PM, Davis T, Hyder AH, Bolton HT, Zeichner BC, Porter SD, Hoch AL, Boswell ML, Williams G (2008) Combining biological and chemical controls for the management of red imported fire ants (Hymenoptera: Formicidae). American Entomologist: 54, 44–53.

Porter SD, Fowler HG, McKay WP (1992) Fire ant mound densities in the United States and Brazil (Hymenoptera: Formicidae). Journal of Economic Entomology 85: 1154–1161.

Tschinkel WR (2006) The fire ants. Harvard University Press, Cambridge.

USDA (2010) Imported fire ant program manual. USDA Animal and Plant Health Inspection Service Plant. Protection and Quarantine.

USDA (2015) Imported fire ant: quarantine treatments for nursery stock, grass sod, and related materials. Program Aid No. 1904, updated January 2015. USDA, Animal and Plant Health Inspection Service.

Wang L, Lu YY, Xu YJ, Zeng L (2013) The current status of research on *Solenopsis invicta* Buren (Hymenoptera: Formicidae) in Mainland China. Asian Myrmecology 5: 125–138.

Williams DF, Oi DH, Porter SD, Pereira RM, Briano JA (2003) Biological control of imported fire ants (Hymenoptera: Formicidae). American Entomologist 49: 150-163.

Appendix

High. Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.

Medium. Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (for example tropical regions) to guarantee that the results will be transposable.

Low. Data are not published in reliable information sources and methods are not commonly practiced or are based solely on opinion; this is for example the case of a novel situation where there is little evidence on which to base an assessment.

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