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Global distribution of the date stone beetle, *Coccotrypes dactyliperda* (Coleoptera: Curculionidae, Scolytinae)

Dirk HR Spennemann

Institute for Land, Water and Society; Charles Sturt University; PO Box 789; Albury NSW 2640, Australia.

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ABSTRACT. The paper presents a compilation of the documented occurrence of the date stone beetle *Coccotrypes dactyliperda* across the globe. The data presented here have been compiled based on an exhaustive search of academic journal databases, collections presented in research portals and digitised holdings of national libraries. A visualisation of the global distribution shows that the presence of *Coccotrypes dactyliperda* is circumscribed by climatic factors.

Key words: biogeography, historic ecology, palm

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Introduction

The date stone beetle, *Coccotrypes dactyliperda* (Fabricius, 1801) is a is a cryptic spermatophagus beetle of the Curculionidae family (Coleoptera: Curculionidae: Scolytinae: Dryocoetini), which was originally endemic to the Middle East where it was associated with the date palm horticultural complex After emergence from hibernation, the first generation of female beetles to leave the brood chamber emerges during late July/early August and attacks green drupes of the date palm (*Phoenix dactylifera*), causing the bulk of these to abscise one to two days later. The species also predates the seeds of fallen dates, often after the pericarp has been consumed by other animals, such as rodents. This continues until August, when a second generation emerges from the seeds. The rate of abscission varies, but when the infructescences are not protected from beetle attack by chemical or physical (bags) means, production losses usually range between 20 and 40%. *Coccotrypes dactyliperda* feeds the albumen in the seeds of a wide range of palm species. It has been documented to feed on other seeds as well but oviposition does not occur (for a review of the biology and ecology of the species see Spennemann, 2019a).

Following an unexpected mass emergence of *Coccotrypes dactyliperda* in a germination experiment of animal dispersed *Phoenix canariensis* seeds (Spennemann et al., 2018), it was necessary to carry out background research on the biology and ecology of that beetle species (Spennemann, 2019a). In the process it

Corresponding author: Dirk HR Spennemann, E-mail: *dspennemann@csu.edu.au*

became clear that the species had attained a global distribution with humans as vectors. Dispersal occurred primarily in the form of date fruits for consumption, as seeds for horticultural endeavours and as vegetable ivory for button manufacture. While numerous sources made reference to the 'cosmopolitan' nature of the species, a systematic documentation of its distribution was conspicuously absent.

Material and methods

This brief study collates and places on record the documented occurrence of *Coccotrypes dactyliperda* across the globe. The data compiled here are based on a systematic search of academic journal databases, such as Primo, Scopus, GoogleScholar, systematic searches of Google as well as full-text searches of research portals, such as the Biodiversity Heritage Library (2018) and digitised holdings of national libraries, such as *Gallica* maintained by the Bibliotheque national de France (2018), or *Trove* maintained by the National Library of Australia (2018). Search terms were both formal (*i.e.* "dactyliperda + country") and informal ("common name + country"), whereby care was exercised to use both current and past country names (e.g. Sri Lanka and Ceylon, Myanmar and Burma, etc.).

In the literature the beetle is often addressed under its common names, *i.e.* 'date stone beetle,' 'date stone weevil,' 'palm seed borer,' 'Dattelkernborkenkäfer,' 'charançon des noyaux de dates,' 'scolyte des dates,' 'tomique du dattier' and 'palmzaadkever.' In addition, given its proclivity to also infest palm seeds that were sources of vegetable ivory used for button manufacture, the species is also known as '(ivory) button beetle' and 'Steinnusskäfer'.

As it is not possible in a compilation such as this to re-verify each original identification, and thus relies on the accuracy of the original source, it must be noted that the species identification of the instances compiled in Table 1 must be read *cum grano salis*.

Terminology

The status of the species in the various countries (Table 1) has been classified as follows. '*naturalised*' are observations where the *Coccotrypes dactyliperda* have established breeding populations outside their endemic range and in the natural environment. Classified as '*introduced*' are observations where *Coccotrypes dactyliperda* have been recorded as arriving in a given country, but where the beetles cannot establish breeding populations outside environmentally controlled environments (such laboratories, greenhouses of nurseries and store/ware houses).

Results

The systematic literature review yielded 238 references that refer to the presence of *Coccotrypes dactyliperda*. The compilation comprises of 214 locational entries (Table 1) in 104 countries (Table 2). The beetle can be found on all continents bar Antarctica.

Discussion

When considering the publications chronologically, the identification and descriptive effort showed a steady increase on a decadal basis, with the effort significantly expanding in the past two decades (Figure 1). The descriptive effort changed its geographic focus over time, concurrent with increased opportunity to work outside Europe. In the nineteenth century the overwhelming majority were reports derived from European locations (Table 2). During the twentieth century the effort expanded globally.

When considering the data geographically, we note a high number of

records the areas where the beetle is endemic with every country represented, followed by a high representation in Europe (both naturalised and introduced) and Central and Southern Africa (naturalised). Other regions are less well represented (Table 3).

The documented records of the global distribution (Table 1) have been mapped in Figure 2. Plotted is the representation by country, and where available, at a state or provincial level. This visualisation shows that the presence of *Coccotrypes dactyliperda* is circumscribed by climatic factors. The contiguous nature of the area where it has been documented archaeologically (e.g. Costantini & Audisio, 2000; Panagiotakopulu et al., 2010) and where it can be regarded as endemic is evident. There are also clear zones both to the north and south where the species has become naturalised, as well as peripheral zones where it is on record as introduced by where it does not thrive (Table 1). These zones are circumscribed by both temperatures, in particular frost, and by humidity. A number of peripheral areas, in particular in Africa south of the Sahara (*i.e.* Mauretania, Mali, Niger and Chad) currently lack positive records of the beetle's presence. While given the comparative dryness in most areas this may reflect reality, it is more likely due to a lack of comprehensive research.

Coccotrypes dactyliperda, while originally associated with the true date palm *Phoenix dactylifera*, readily infests the Canary Islands date palm, *P. canariensis*. The nineteenth and early twentieth century horticultural trade in this palm as an ornamental species in private and public spaces (Spennemann, 2018a, 2019b; Zona, 2008), led to a global distribution in all subtropical, temperate zones of the world (Spennemann, 2018b). This it is likely that *C. dactyliperda* will have also distributed as part of that trade.

Table 1. Distribution of *Coccotrypes dactyliperda* in the world.

Country	Status	Comments and References
North Africa		
Algeria	endemic	(Anonymous, 1846; Lucas, 1849); *et seq*. (Decaux, 1890; Fleutiaux, 1901) El-Kala (Lucas, 1846) various oases (Balachowsky, 1949)
Egypt	endemic	(Attia & Kamel, 1965; Boraei, 1994; Gentry, 1965; Mostafa et al., 2017) Alexandria (in dum nut buttons) (Schedl, 1959) Nile Delta (in dates) (Donia et al., 2002) northern Sinai (El-Sherif et al., 1998) Siwa Oasis, 1935 (Schedl, 1950) Sharkia (Willcocks, 1913 [1914]) El-Bahria Oasis (Ali et al., 2002, 2003)
Libya	endemic	(significant pest: Gentry, 1965)

Table 1. Continued

Country	Status	Comments and References
		Bengasi (Scaëtta, 1926); 1922 Bengasi (Gridelli, 1930) Zanzur Coastal Oasis (Martin, 1958) Tripoli Coastal Oasis (Martin, 1958) Tagiura Coastal Oasis (Martin, 1958) Latrun Coastal Oasis (Martin, 1958) Ras el Hilal Coastal Oasis (Martin, 1958)
Morocco	endemic	(Ait-Oubahou & Yahia, 1999) Faroudant (Schedl, 1971)
Sudan	endemic	(Schedl, 1948) Khartoum (Gredler, 1877)
Tunisia	endemic	(Anonymous, 1846) *et seq.* (Decaux, 1890; Macquardt, 1852; MEDD, 2009) Djerba (Balachowsky, 1949)
Middle East		
Iran	endemic	(Latifian, 2016) not listed: (Shafiean, 2017)
Iraq	endemic	(Bureau of Entomology and Plant Quarantine, 1950)
Israel	endemic	(Bodenheimer, 1937) *et seq.* (Gentry, 1965; Zchori-Fein et al., 2006) Lake Kinneret (Schedl, 1969) Bet She'an Valley (Bar-Shalom & Mendel, 2001); in stored dates (uncommon occurrence) (Donahaye & Calderon, 1964) Upper Jordan Valley (Kehat et al., 1974)
Jordan	endemic	(Mashal & Albeidat, 2006); reputedly absent in the Southern Jordan Valley (Al Antary et al., 2015; Bar-Shalom & Mendel, 2001; Kehat et al., 1976)
Lebanon	endemic?	presumed endemic, no references found
Syria	endemic?	presumed endemic, but reputedly non-existent: (Syrian Government, 2009); not reported in Hussain (1974).
Oman	endemic	(Elwan, 2000)
Palestine	endemic	Gaza Strip (Bar-Shalom & Mendel, 2001; Radwan, 2017), present West Bank (Bar-Shalom & Mendel, 2001; Kehat et al., 1976) reputedly absent in the Southern Jordan Valley
Saudi Arabia	endemic	(Al Dhafer & Alayeid, 2014; Belala et al., 1999; Hammad et al., 1981)
Central and Southern Africa		
Cameroon	naturalised	(Schaufuss, 1905)
Djibouti	naturalised	(Fairmaire, 1892)

Table 1. Continued

Country	Status	Comments and References
Equatorial Guinea	naturalised	(Hagstrum & Subramanyam, 2009)
Eritrea	naturalised	ca 1907 (Del Guercio, 1919) *et seq*. (Abate, 1988)
Ethiopia	naturalised	(Azerefegne et al., 2009)
Kenya	naturalised	coastal strip (Gardner, 1957)
Liberia	naturalised	(Bureau of Entomology and Plant Quarantine, 1928)
Madagascar	naturalised	(Schedl, 1961, 1977)
Malawi	naturalised	(Hagstrum & Subramanyam, 2016)
Mauritius	naturalised	(Schedl, 1961)
Mozambique	naturalised	(Schedl, 1961)
Nigeria	naturalised	(Aisagbonhi, 1988)
Senegal	naturalised	(Schedl, 1961)
Seychelles	naturalised	(Schedl, 1977) Mahé (Beaver, 1987b; Pelsue & O'Brien, 2009)
Sierra Leone	naturalised	(Hagstrum & Subramanyam, 2016)
Somalia	naturalised	ca 1907 (Del Guercio, 1919)
South Africa	introduced	(Schedl, 1957) Durban, Natal (Van der Merwe, 1921, 1923) in buttons, but self-sustaining Port Elizabeth (Van der Merwe, 1921) in buttons
	naturalised	Pretoria, Transvaal 1915 (Schedl, 1961) origin not specified Kelly Hill, KwaZulu-Natal (Schedl, 1961) origin not specified
Tanzania	naturalised	(Hagedorn, 1913) Tanga 1918 (Schedl, 1959)
Uganda	naturalised	(Hargreaves, 1922) Kampala 1932 (Schedl, 1959)
Europe		
Austria	introduced	(Reitter, 1894; Sturm, 1826); Kärnten (Pacher, 1853) Oberösterreich, found in imported dates (Dalla Torre von Thunberg-Sternhoff, 1880; Schilsky, 1889) Niederösterreich, found in imported dates but not naturalised (Wichmann, 1927) Vienna found in imported dates but not naturalised (Wichmann, 1927, 1955); rare (Redtenbacher, 1874) South Tyrol 1873 (Gredler, 1873; Targioni Tozzetti, 1874)
Belgium	introduced	(Lameere, 1900) Namur (Vreurick, 1910) Liege (Eichhoff, 1879)

Table 1. Continued

Country	Status	Comments and References
Croatia	introduced	Zagreb and Rijeka, in imported dates but not naturalised (Ernõ, 1922; Langhoffer, 1915a, 1915b)
Cyprus	naturalised	(Gentry, 1965)
Czech Republic	introduced	1824 (Opiz, 1824); <1900 (Šefrová & Laštůvka, 2005)
Denmark	introduced	Copenhagen, in imported dates and betel nuts 1877, (Lovendal, 1889; Løvendal, 1898)(Hansen, 1956)
England	introduced	(Duff, 2012); (Wakely, 1943) in dates; Middlesex Oct 1920 (Ashby, 1941); Glamorgan, Wales (Tomlin, 1935)
France	introduced	(Fleutiaux, 1901; Grenier, 1863; Vérardi & Joly, 1852) Paris in dates 1803 (Latreille, 1803) *et seq*. (Boitard, 1828, 1834; Dejean, 1837; Latreille, 1825; Rengade, 1866) Alsace, in date seeds, rare (Wencker & Silbermann, 1866) Bordeaux, in dates (Commission Entohologique, 1853) Lyon, in date seeds (Locard, 1877; Rey, 1892) Reims, in date seeds (Warnier, 1895) (offered for swap) Seine-Inférieure, in date seeds, common (Mocquerys, 1857)
	naturalised	(Decaux, 1890) coast of the Mediterranean, very common (Balachowsky, 1949); Marseille (de Boissy, 1921) South-West (Balachowsky, 1949) Midi (de Boissy, 1921) Brittany (Balachowsky, 1949) Corsica (Balachowsky, 1949) acclimatized, very common
Germany	introduced	(Bureau of Entomology and Plant Quarantine, 1933) Bavaria (Kittel, 1883) Silesia, Breslau 1838 (Letzner, 1840), 1877 (Rudel, 1877) Thuringia, Erfurt (Hubenthal, 1926) Hamburg (Hagedorn, 1904)*et seq*. (Weidner, 1964) Rhineland (Bach, 1854)
Gibraltar	naturalised	(Perez & Bensusan, 2017)
Greece	naturalised	(Vassilaina-Alexopoulou et al., 1986) Crete (Hellrigl, 2002) acclimatised
Hungary	naturalised	(György & Podlussány, 2005)
Iceland	introduced	(Comparini et al., 2018)

Table 1. Continued

Country	Status	Comments and References
Italy	introduced	northern Italy (Abbazzi et al., 1995) Trento, South Tyrol (De Bertolini, 1872) Milan (Schedl, 1961) Lombardy (De Bertolini, 1872) (but see below, Sarca Valley)
	naturalised?	Genoa (Bernabò, 1990) but absent in 1990
	naturalised	Piedmont (Baudi, 1889; Porta, 1932) Lombardy (Porta, 1932) Sarca Valley, Lombardy (Wichmann, 1955) southern Italy (Abbazzi et al., 1995) Puglia (Longo et al., 1991) Basilicata (Longo et al., 1991) Liguria (Porta, 1932) Campania (Porta, 1932) Lazio (Porta, 1932) Calabria (Longo et al., 1991; Schedl, 1961) Ischia (Buchner, 1961) Sardinia (Bargagli, 1873; Gatti, 2011; Ragusa, 1924) Sicily (Kirkendall & Faccoli, 2010; Ragusa, 1924) Lipari I., Aeolian Islands (Lapiana & Sparacio, 2006)
Malta	naturalised	(Mifsud & Knížek, 2009)
Monaco	naturalised	(Ponel et al., 2011)
Montenegro	naturalised	(Comparini et al., 2018) (Roganović, 2013)
Netherlands	introduced	(Vorst, 2010)
Poland	introduced	Galicia (Kleine, 1913a); Silesia (Gerhardt, 1910)
Portugal	naturalised	(Bureau of Entomology and Plant Quarantine, 1943)
Romania	introduced	Transylvania(Seidlitz, 1891)
Russia	introduced	Leningrad Region (Mandelshtam & Popovichev, 2000; Chilakhsaeva, 2011) introduced, not acclimatised Yaroslavl Region (Chilakhsaeva, 2011) introduced, not acclimatised
Spain	naturalised	Valencia, naturalised by 1872 (Arcas, 1873) Elche naturalised by 1869 (Dieck, 1870) *et seq.* (Gómez Vives, 2004) Barcelona (Guni y Martorell, 1888; Kleine, 1913b; Rosiqué et al., 2018) Mallorca (Bathon, 2007; Comparini et al., 2018)
Switzerland	introduced	Neuchatel 1842 (Siebold, 1846) in date seed; Schaffhausen (Stierlin, 1866, 1906) in date seed
Turkey	naturalised	(Bureau of Entomology and Plant Quarantine, 1951) İzmir (Fleutiaux, 1901)
Ukraine	introduced	Ternopil (Rybinski, 1903) at railway station

Table 1. Continued

Country	Status	Comments and References
Asia and South East Asia		
China	naturalised	(Yan et al., 2010)
India	naturalised	Bengal, Calcutta (Blanford, 1895); Bombay (South Kanara) (Beeson, 1939) Kerala (Daniel & Kumar, 1979; Nair & Oommen, 1968) Karnataka (Daniel & Kumar, 1979) Maharastra (Malti & Saha, 2009) Punjab (Batra, 1972; Sohi & Batra, 1972) (since ca 1969) United Provinces (Beeson, 1939) Uttarakhand (Roonwal, 1971) Tamil Nadu (Rao & Janaki, 1953; Roonwal, 1971) Uttar Pradesh (Malti & Saha, 2009)
Indonesia	introduced	Bogor 1923 (ex Australia) (Kalshoven, 1958)
Japan	naturalised	(Goto, 2009)
Malaysia	naturalised	(Beeson, 1939). Penang (Beaver & Browne, 1978)
Myanmar	naturalised	(Hagstrum & Subramanyam, 2016)
Singapore	naturalised?	(Browne, 1961)
Sri Lanka	naturalised	(Speyer, 1918) *et seq*. (Beeson, 1939; Roonwal, 1971; Schedl, 1959)
Thailand	naturalised	(Beaver & Browne, 1975) Chiang Mai (Schedl, 1961) as *Coccotrypes laboulbenei*
Vietnam	naturalised?	Saigon (Schedl, 1961)
Oceania		
Australia	naturalised	New South Wales (Spennemann et al., 2018) Queensland (Spennemann et al., 2018) Northern Territory (Spennemann et al., 2018) Norfolk Island (Director of National Parks, 2018)
Bonin Islands	naturalised	(Nobuchi, 1985)
Fiji	introduced	Viti Levu, from dates 1918, not established (Beaver, 1987a) Ovalau (Bryan, 1924)
Galapagos Islands	naturalised	(Bright & Peck, 1998)
Hawai'i	naturalised	1916 (Swezey, 1928) Kauai 1927 (Schedl, 1941); 1928 (Swezey, 1941) Hawai'i 1931 (Schedl, 1941; Swezey, 1932, 1941) Oahu1907 (Schedl, 1941, 1948; Swezey, 1928, 1941)
New Caledonia	naturalised	(Balachowsky & Mesnil, 1935)
New Guinea	introduced	New Britain 1935 (Schedl, 1942)
	naturalised	(Setliff, 2007) Madang (Iamba et al., 2018)
Ogasawara Islands	naturalised	(Ogasawara Islands, 2017)

Table 1. Continued

Country	Status	Comments and References
New Zealand	naturalised	(Brockerhoff et al., 2006; Bureau of Entomology and Plant Quarantine, 1945); Auckland 2000 (Brockerhoff et al., 2003); Whangarei 2000 (Brockerhoff et al., 2003)
Solomon Islands	naturalised?	(Hagstrum & Subramanyam, 2016)
Atlantic Islands		
Azores	naturalised	(Meijer et al., 2011)
Canary Islands	naturalised	(Berg et al., 2003); Gran Canaria (Garcia, 1991); Teneriffe (Siverio & Montesdeoca, 1990)
Cap Verde	naturalised	(Hernández & González, 2011)
Madeira	naturalised	(Hagedorn, 1910b; Município de Santana, 2012; Schedl, 1963)
Caribbean		
Bahamas	naturalised	(Barriga-Tuñón & Kirkendall, 2017)
Bermuda	naturalised	(Ogilvie, 1928); but no longer in 1989(Hilburn & Gordon, 1989)
Costa Rica	naturalised	(Bureau of Entomology and Plant Quarantine, 1950)
Cuba	naturalised	(Blackwelder, 1947; Cruz et al., 2008; Peck, 2005)
Jamaica	naturalised	(Bright, 1985)
Montserrat	naturalised	(Ivie et al., 2008)
Puerto Rico	naturalised	(Bright, 1985; Bright & Torres, 2006; Medina Gaud & Martorell, 1973)
Trinidad	naturalised	1950 (Bureau of Entomology and Plant Quarantine, 1951); 1952 (ALA, 2018); (Bright, 1981)
South America		
Argentina	naturalised	(Blackwelder, 1947; Schedl, 1966)—Buenos Aires (Begrano, Isla Martin Garcia, Cap Federal) (Schedl, 1961); Entre Rios (Concordia) (Schedl, 1961)
Brazil	naturalised	1948 (Nunberg, 1958); (Schedl, 1966); Minas Gerais (Schedl, 1972)
Chile	naturalised	Antofagasta (Kirkendall, 2018; Schedl, 1972)
Colombia	naturalised	(Blackwelder, 1947)
Ecuador	naturalised	(Campos, 1929; De Sanabria, 1921; Hagedorn, 1904)
Guyana	naturalised	(Hagedorn, 1910a; Nunberg, 1958)
Panama	naturalised	(Blackwelder, 1947; Bureau of Entomology and Plant Quarantine, 1951) Canal Zone (Schedl, 1959)
Peru	naturalised	1942 (Nunberg, 1958); Amazon (Delobel et al., 1995)
Uruguay	naturalised	(Ruffinelli, 1967; Schedl, 1948)
Venezuela	naturalised	(Blackwelder, 1947)

Table 1. Continued

Country	Status	Comments and References
North America		
Mexico	naturalised	(Atkinson & Martínez, 1985); Cuernavaca (Atkinson et al., 1986); Baja California del Sur (Linsley, 1943; Romero, 2017)
U.S.A.	introduced	(Fauvel, 1889a, 1889b) et seq. (Hamilton, 1894) Chicago (Riley, 1894) in Italian exhibit at the 1893 World Fair; Washington, DC (Ulke, 1903) in dates New York (Swaine, 1909)
	naturalised	(Blake & Russel, 1943) Arizona (Wood & Bright, 1992) California, acclimatised pre 1926 (Van Dyke, 1927) et seq. (Bright & Stark, 1973; Holzman et al., 2009; Linsley, 1943; Seybold et al., 2016; Swezey, 1941) Los Angeles (Van Dyke, 1927) Riverside City (Van Dyke, 1927) Northern Baja California (Horn, 1897) Florida (Atkinson et al., 1991) Texas (Wood & Bright, 1992)

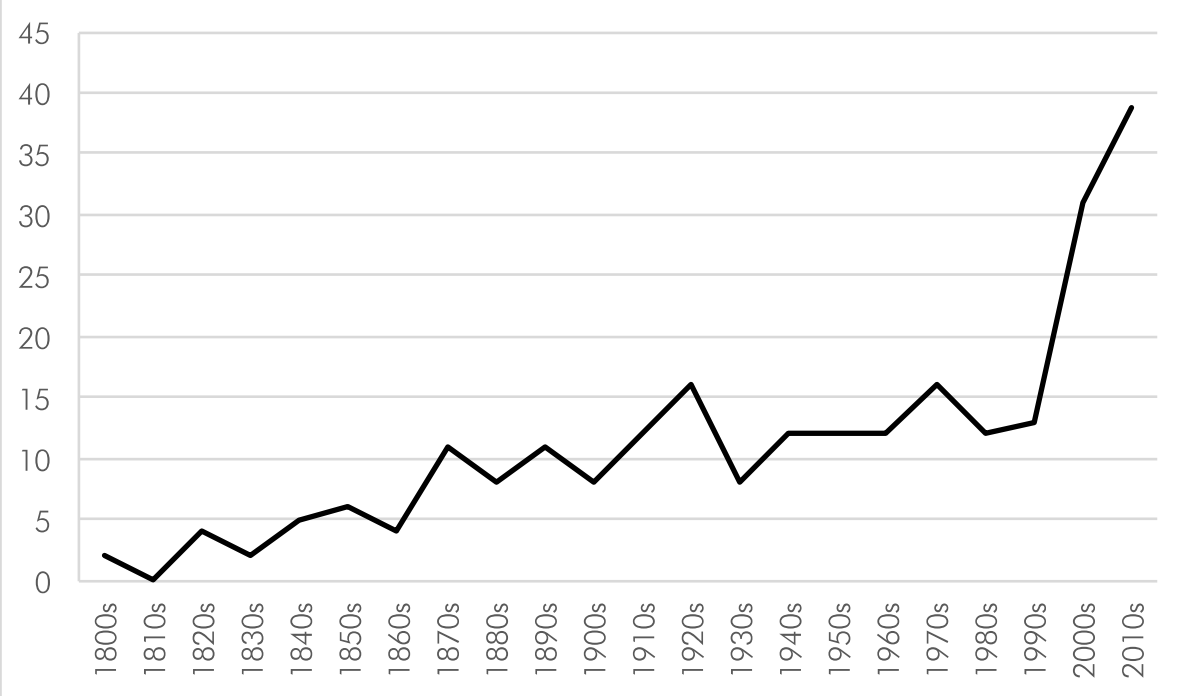

Figure 1. Decadal frequency of publications summarised in (Table 1). The decade 2010 has been scaled up to a full 10 years.

Table 2. Summary of regional representation of *Coccotrypes dactyliperda* (in % per century).

Region	1800s	1900s	2000s
Middle East		7.1	12.9
North Africa	11.1	12.1	6.5
Central and Southern Africa	2.8	13.6	9.7
Europe	75.0	29.3	29.0
Asia and South East Asia	2.8	9.3	8.1
North America	8.3	7.9	3.2
Atlantic Islands		1.4	6.5
Caribbean		4.3	8.1
South America		7.9	1.6
Oceania		7.1	14.5
Total	36	140	62

Table 3. Summary of representation of *Coccotrypes dactyliperda* by region and status.

Region	endemic	naturalised	introduced	Total
Middle East	9			9
North Africa	6			6
Central and Southern Africa		19		19
Europe		12	14	26
Asia and South East Asia		9	1	10
North America		2		2
Atlantic Islands		4		4
Caribbean		8		8
South America		10		10
Oceania		9	1	10
Total	15	73	16	104

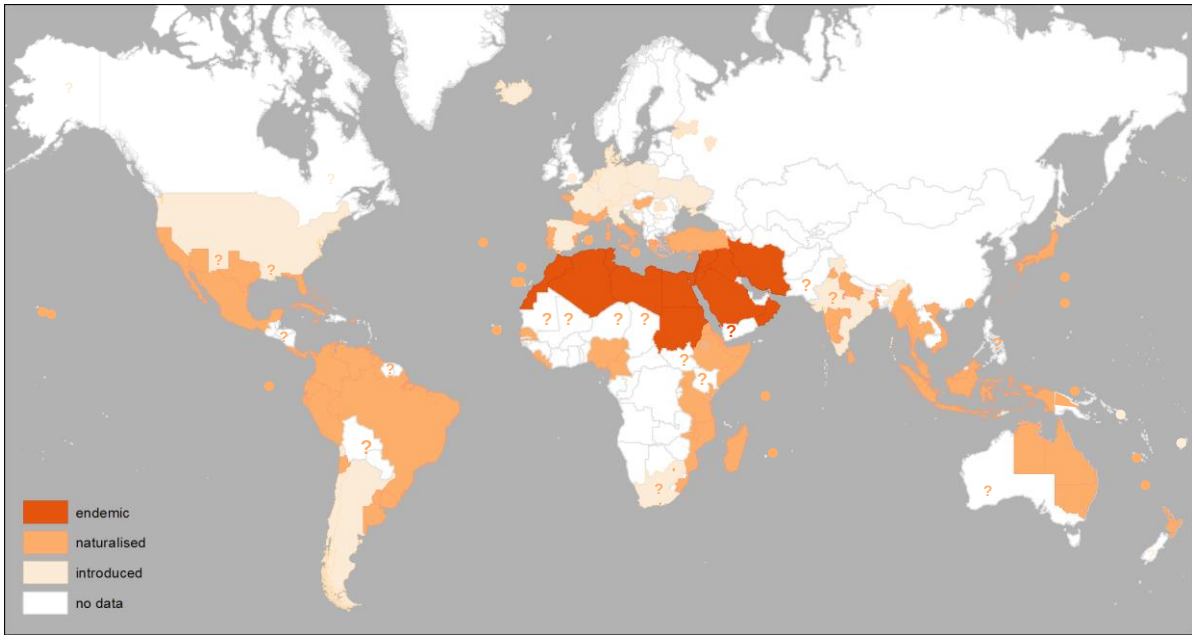

Figure 2. Geographical Distribution of *Coccotrypes dactyliperda*.

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Conflict of Interests

The author declares that there is no conflict of interest regarding the publication of this paper.

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پراکنش جهانی سوسک سنگی خرما *Coccotrypes dactyliperda* (Coleoptera: Curculionidae, Scolytinae)

دیرک اچ آر اسپنمن

مؤسسه خاک، آب و جامعه، دانشگاه چارلز استورت، صندوق پستی ۷۸۹. نیو سات ولز، استرالیا
* پست الکترونیکی نویسنده مسئول مکـاتبه: *dspennemann@csu.edu.au*
تاریخ دریـافت: ۰۸ مهر ۱۳۹۷، تاریخ پذیرش: ۰۴ دی ۱۳۹۷، تاریخ انتشار: ۰۹ دی ۱۳۹۷

چکیــده: مقاله حاضر بر اساس مستندات علمی در مورد پراکنش سوسک سنگی خرما *Coccotrypes dactyliperda* در سراسر جهان تهیه شده است. داده‌ها براساس جستجوی جامع پایگاه‌های مجله‌های دانشگاهی، مجموعه‌های ارائه شده در پورتال‌های تحقیقاتی و منابع دیجیتالی کتابخانه‌های ملی ارائه شده است. مشاهده پراکنش جغرافیایی نشان داد که انتشار سوسک سنگی خرما توسط عوامل اقلیمی محدود شده است.

واژگــان کلیدی: جغرافیای زیستی، تاریخچه بوم‌شناسی، نخل روغنی