PEOPLE, TRANSPORTS AND THE SPREAD OF THE ARGENTINE ANT IN EUROPE, FROM C.1850 TO PRESENT

ANA ISABEL QUEIROZ*
DANIEL ALVES**

Resumo: *A História do Ambiente tem contribuído para a investigação sobre invasões biológicas. Esta estuda os vetores de introdução, as perceções e as respostas das sociedades. As narrativas históricas dos processos de introdução e expansão são uma fonte de conhecimento para ajustar as atuais medidas de prevenção e controlo, destinadas a minorar impactos económicos, ecológicos e no bem-estar das populações. Neste contexto, estuda-se a introdução da formiga-argentina (Linepithema humile Mayr) na Europa desde o século XIX, momento a partir do qual foi considerada como incómoda e prejudicial. Apresenta-se a narrativa da sua expansão combinando material histórico de diferentes fontes, origens e escalas, e examinam-se as vias de entrada ao longo do tempo. Conclui-se que a espécie chegou a diferentes regiões da Europa por processos independentes, associados a viagens e ao comércio, em estreita ligação com a evolução dos transportes.*
Palavras-chave: *Invasões Biológicas; Europa; Comércio e Viagens.*

Abstract: *Environmental history is increasingly contributing to the research on bioinvasions. It investigates the vectors of introduction, people's perceptions and societal responses. Historical narratives of introduction processes and spread may help improve current preventive and management practices designed to mitigate impacts in the economy, ecology and people's well-being. In this framework, we study the introduction of the Argentine ant (Linepithema humile Mayr) in Europe since the nineteenth century when the species was perceived as inconvenient and harmful. A narrative of the expansion combines historical material from different sources, origins and scales and examines pathways through time. We conclude that the species arrived to different regions of Europe through independent processes, associated with travel and trade, and strictly connected with the evolution of transportations.*
Keywords: *Biological Invasions; Europe; Trade and Travel.*

The history of transportations has a prominent place in the national and global historiographies. Circulation around the globe has promoted the exchange of people and goods since the pioneer discoveries of new territories and maritime routes in the fifteenth century. Caravels and other sailing boats allowed for the exchange of influence, cultures and natures, mainly between Europe and the rest of the world, enriching the nations that, directly or indirectly, found themselves involved in this long-term process. The mid-nineteenth century, with its technological development, marked a new era for maritime transports, influenced by the use of steam engines, which fomented economic globalization. At the same time, the railway expanded mainly in Europe and North America. Later on, cars, buses and trucks started competing with the railway (in both travel and trade), becoming more and more popular from the first decades of the twentieth century onwards. Airlines entered the global framework of mobility after the World War II[1]. In

* Instituto de História Contemporânea, FCSH, Universidade Nova de Lisboa.
** Instituto de História Contemporânea, FCSH, Universidade Nova de Lisboa.
1 ROUSSEAU, 1961.

the 1970's, commercial civil aviation became an alternative to maritime trips and even cargo transports.

Evolution in transports had an impact that went beyond the increased mobility of people and economic change. Along with cultural, political and economic globalization, organisms from all taxa – from viruses and bacteria to plants, arthropods and vertebrates – have been intentionally or accidentally carried in several directions. As a consequence, many of the common organisms presently in Europe originate from other geographical regions. The transfer of new species to Europe started early. In the fifteenth and sixteenth centuries, sailors would bring these organisms back to their own countries, as evidence of their stay in exotic places[2].

The worldwide spread of living organisms is closely connected to the European expansion and colonialism, the development of transport and trade routes, migration, and mass tourism. But the newly introduced species cause varied cultural responses. People love, ignore or hate 'bio-invaders'. Furthermore, biological characteristics – such as range, demography, dispersal and habitat preferences – do not coincide with imposed divisions of time (eras, epochs, decades, etc.) and space (continents, countries, municipalities, etc.), used by historians to handle social and geographical complexity[3]. Thus, understanding the natural patterns of species dispersion and how people influenced their spread is a complex task which requires an integrated analysis and the development of multiple views, from local to global.

In addition to the biological approach, other perspectives should be taken into account. Research derived from the humanities perspective can transform our understandings of the character and implications of invasion ecology. As the number of non-native species in many ecosystems continues to grow, the cultural dimension of this topic is increasingly recognised as crucial.

In the 1970s, environmental historians started establishing a connection between nature and culture in the context of the global circulation of species[4]. Their focus has since been on the motivations behind human transport of species and the vectors used to move them, either intentionally or unintentionally, as well as the effect these species have on human societies. The history of bioinvasions also demonstrates how technological advances in transportation, travel and consumption habits have contributed to a long-term problem that still causes relevant economic losses and that is considered by conservationists to be an important cause for biodiversity loss worldwide. Recently, there have been various cultural approaches to bioinvasions, namely by geographers, philosophers, historians, economists, and legal scholars. This interdisciplinarity allows for a better understanding and management of the invasive species[5]. The need to rethink invasion comes from the nature/culture challenge thus enunciated: the way species interact within bio-cultural environments, rather than their individual biological characteristics, results

2 FERRÃO, 1992.
3 BODENHAMER, 2008.
4 See CROSBY, 2004; GROVE, 1996; MCNEILL, 1976.
5 See KELLER, 2014.

in the formation of invasion ecologies, which sometimes include multilayered geographies that can be local, regional, national and global[6].

A variety of injurious organisms, including plant pests, were accidentally scattered through transport and trade pathways. These invasive species altered human society, contributing to poverty, hunger and migration, and leading to economic and political changes. History records dramatic cases, most of them resulting from introduced organisms[7]. The Argentine ant (*Linepithema humile*) is an example of a small insect native to the Paraná River basin in subtropical South America[8] that spread around the globe, travelling by human agency, and which had a severe impact on ecology, economy and human welfare[9]. It is now established in South America (inside and outside its native range), North America, Europe, Africa, Asia, Australia and many islands in the Atlantic, Indian and Pacific oceans. The European range of the Argentine ant comprises the first recorded invasion outside South America[10].

Several biological and behavioral characteristics have been key to the success of the Argentine ant. Literature characterizes this species as omnivorous, stating that it lacks natural predators, parasites or other native ant competitors; there is no reference to aggression among specimens from different nests, and they don't have an hibernation period in areas under invasion (mainly in Mediterranean-type climate areas; indoors, in less mild climatic areas), which allows them to colonize new areas and force native species in physiological stop to retreat[11]. Any place in which it can find abundant diet resources, the Argentine ant reaches tremendous numbers. In buildings, they create nests within cracks and grooves of the structure itself, for protection, and invade all places with food or water, like kitchens and toilets. In their search for secretions and body fluids, moist and rich in nutrients, they may attack humans, especially the most vulnerable. The short story «The Argentine ant», by Italo Calvino (1952), is a vivid fictional narrative that portrays how the species could be unbearable. As a plant pest, it favors trees and shrubs infested with aphids, mealybugs and soft-scale insects, for it consumes their secreted honeydew, making these plants the perfect habitat for this species. The ant also protects the hemipterans while they are weakening the plants.

The Argentine ant is a major source of interest for the natural science community, which has been trying to find the origins of the introduced populations and comparing their genetic material with that of the specimens collected in the native range or else-

6 FRAWLEY & McCALMAN, 2014.

7 BRAA, 1997; MARTINS, 1991; PAULY, 2002.

8 This species was described for the first time in 1868, from specimens collected in 1866 near Buenos Aires, Argentina. It received the scientific name of Hypoclinea humilis, afterwards Iridomyrmex humilis. Today, the entomologists refer to it as Linepithema humile. MAYR, 1868. In the first published reports of invasions the species was referred only by its latin name by FOREL, 1895 and SCHMITZ, 1896, or by other common names, such as «New Orleans ant» TITUS 1905 and formiga-ladra, by MARTINS, 1907. The Argentine ant has been popularized by the works of Woodworth, 1910 and Newell & Barber, 1913, authors that knew the origin of the type-specimens and adopted it to distinguish these particular ants from other species.

9 *Linepithema humile. 100 of the World's Worst Invasive Alien Species. Global Invasive Species Database.* 2005. [accessed 1 February 2016] at <URL http://www.issg.org/database/species/search.asp?st=100ss>.

10 WETTERER *et al.*, 2009.

11 For a review, see DIAZ BUITRAGO, 2012.

where[12]. These studies are crucial for the reconstruction of the history of invasion, but they overlook the cultural, social and economic factors that determine and explain the arrival, the invasion and the subsequent responses[13].

The Argentine ant was chosen as a case-study because its spread cannot be generally explained by budding (the natural process) but, rather by human-mediated transport of colonies[14]. Scientific papers and global databases have already charted the spread of the Argentine ant around the world and devised georeferenced records of its non-native range[15]. However, the only chronological history of the invasion for this species at a continental scale pertains to the United States, which relies on literature reviews, museum records and personal surveys[16].

Analysing the chronological occurrences of the species and highlighting the first records by country or by archipelago, this paper examines the historical process of introducing the Argentine ant into non-native territories and its consequences for nature and society. Building on previous work addressing the worldwide spread of the Argentine ant in its natural dimension, it offers a complementary analysis of how transportation facilities contributed to new occurrences in Europe, it examines the societal responses to outbreaks, and it points out the ways in which past occurrences can help prevent future introductions of similar organisms. By relating the ant's arrival, establishment and outbreak to the evolution of transports and changes in patterns of travel, trade and consumption, it integrates «ecological, socioeconomic, and cultural information into coherent narratives of change over time (…) clear, critical, and comprehensible [narratives] for policy makers and practitioners»[17].

METHODOLOGY

Spatio-temporal data from the end of the nineteenth century onwards were extracted from scientific publications (60%), academic theses (4%), official documents (29%), and media (7%). Broader perspectives are achieved by integrating scientific discourse with anecdotal descriptions, legal texts and propaganda[18]. The official documents analysed in this article, dating from 1920 to 2014, report on the ant infestation, nationally and internationally, and look for a better understanding of its impact on agriculture, and the environment in general. In addition, they report on control measures taken to mitigate impacts (these, mainly

12 VOGEL *et al.*, 2010. On 4 April 2015, a search in Google Scholar with the topic «Argentine Ant» found 7560 results in total (any time), 5820 from the period 2000-2015, and 110 from the early 2015.
13 CORIN *et al.*, 2007; TSUTSUI *et al.*, 2001.
14 SUAREZ *et al.*, 2001; WETTERER *et al.*, 2009.
15 DAISIE – *Species Factsheet. Delivering Alien Invasive Species Inventories for Europe*. [accessed 24 August 2015] at <URL http://www.europe-aliens.org/speciesFactsheet.do?speciesId=51083>; Identification guides and checklists of plants and animals. Discover Life. [accessed 24 August 2015] at <URL http://www.discoverlife.org/mp/20q>; Taxon Details. Fauna Europaea>. [accessed 24 August 2015] at <URL http://www.faunaeur.org/full_results.php?id=81173>; WETTERER *et al.*, 2009.
16 SUAREZ *et al.*, 2001.
17 POOLEY, 2013.
18 Whenever texts are originally in other languages different from English, the transcribed translations are of our own responsibility.

between 1920 and 1950). Newspapers and internet resources are especially useful to understand public perceptions of the invasion, for particular times and places.

Relevant information was linked to geographical coordinates in a relational database that was built to compile different kinds of data, and to record spatio-temporal references to the Argentine ant (mentioned by one of the synonymous scientific names in Latin, or common names in the different languages) that we call 'occurrences'. The first record of occurrence is an indicative mark of establishment. It results both from an incidental discovery (e.g. a scientific inventory or the collection of specimens) and a notorious natural phenomenon that attracted public attention, including that of scientists.

In the next section, an historical narrative reviews the compiled information, following the ant's European non-native range over different periods in time, and describes the societal responses to outbreaks. The Argentine ant's occurrences were assessed in four periods, each period was defined according to the historical development of transportation and the relative importance of ships, trains, trucks, airplanes and private vehicles over time, as briefly described below:

a) the nineteenth century: the railway and steamships were dominant during the second half of the century (n=8);
b) from 1900 to 1929: cargo ships operated regularly; on land, the railway was the prime way for travel and transportation, although combined with the first cars, coaches and trucks that could reach more destinations (n=51);
c) from 1930 to 1969: the road transport was the prime way for travel and transportation of goods, surpassing the railway (n=52); cargo ships operated regularly;
d) from 1970 to 2014: although cargo ships continued to be relevant in a new wave of global trade, in these last few decades, planes were established as the main mean of transport for people for long and medium distances; private vehicles were popular for short distances (n=54).

We focus on «pathways throughout time», the geographical routes by which the species moved outside its natural range, the corridors of introduction and the human activities that gave rise to an introduction. Moreover, the ways in which transportation facilities contribute to new occurrences in Europe, from the middle of the nineteenth century onwards, are analysed. We conclude by revising the essential historical features of the Argentine ant dispersion integrating them with other invasive species and lessons for the future.

SPREAD AND PATHWAYS THROUGHOUT TIME

Figure 1 shows the historical distribution of the Argentine ant in its European range, based on records of occurrence by periods. The maps do not represent the level of invasion in each country or region but the spread of the species across Europe and throughout time, indicating the existence of at least one reference for each period (shaded areas) and, when known, the first record in each country or archipelago (see Table 1).

Table 1 – First records by countries and regions.

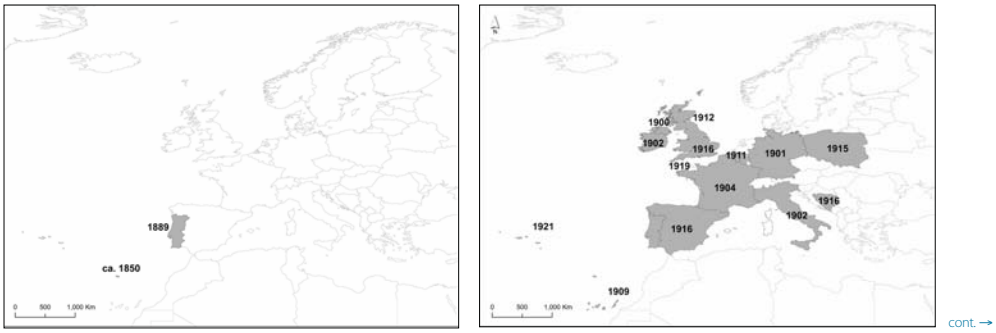
DATE	LOCAL/REGION	COUNTRY	REFERENCES
Ca.1850	Madeira islands	Portugal	WETTERER *et al.*, 2007.
1889	Portugal mainland [Lisboa]	Portugal	MARTINS, 1907.
1900	Northern Ireland [Belfast]	UK	DONISTHORPE, 1927 *apud* CARPENTER, 1902.
1901	Germany [Niemiec-Hamburg]	Germany	PISARSKI, 1957 *apud* STITZ, 1939.
1902	Ireland	Ireland	WETTERER *et al.*, 2009 *apud* CARPENTER, 1902.
1902	Italy mainland	Italy	WETTERER *et al.*, 2009 *apud* SILVESTRINI, 1922.
1904	France mainland [Bouches-du-Rhone, Nice, Alpes Maritimes and Cannes]	France	BLANCK, 1949.
1909	Canary islands	Spain	WETTERER *et al.*, 2009 *apud* STITZ, 1916.
1911	Botanical Garden of Brussels	Belgium	WETTERER *et al.*, 2009 *apud* BONDROIT, 1911.
1912	Scotland [Edimburg]	UK	DONISTHORPE, 1927.
1915	Botanical Garden of Wroclaw	Poland	PISARSKI, 1957 *apud* PAX, 1915.
1916	England [Enfield and Eastbourne]	UK	DONISTHORPE, 1927.
1916	Spain mainland	Spain	WETTERER *et al.*, 2009 *apud* FRISQUE, 1935.
1916	Bosnia	Bosnia	
1919	Guernsey	UK	DONISTHORPE, 1927.
1921	Azores islands	Portugal	CHOPARD, 1921.
1921	Monaco	Monaco	
1926	Sicily	Italy	DONISTHORPE, 1927.
1947	–	Czech rep.	WETTERER *et al.*, 2009 *apud* NOVAK, 1947.
1952	–	Austria	WETTERER *et al.*, 2009 *apud* HOLZEL, 1966.
1953	Balearic islands [Mallorca]	Spain	BERNARD, 1956.
1957	Corsica	France	BERNARD, 1957.
1967	Greece mainland	Greece	WETTERER *et al.*, 2009 *apud* BERNARD, 1968.
1968	–	Malta	WETTERER *et al.*, 2009 *apud* BARONI URBANI, 1968.
1971	Sardinia	Italy	CASEVITZ – WEULERSSE, 1974.
1976	–	Netherlands	BOER AND VIERBERGEN, 2008.
1980	–	Switzerland	WETTERER *et al.*, 2009 *apud* KUTTER, 1981.
1995	–	Sweden	WETTERER *et al.*, 2009 *apud* DOUWES, 1995.
1997	–	Andorra	ESPADALER, 1997.
2003	–	Bulgaria	DAISIE, 2003.
2004	Crete	Greece	WETTERER *et al.*, 2009 *apud* RADCHENKO, 2004.
2004	Sandnes	Norway	GÓMEZ *et al.*, 2005.
2005	Embiez Islands	France	BERVILLE, 2013 *apud* BLANC, 2006.
2006	Hyères Islands	France	
2013	Aegadian Islands	Greece	BERVILLE *et al.*, 2014.
2013	Aeolian Islands Pantelleria, Pelagie and Ustica	Italy	MITROIU, 2013.
2013	–	Kosovo	
2013	–	Montenegro	
2013	–	Serbia	
2013	–	Voivodina	

The Nineteenth Century

Recently, scientists have found a few forgotten specimens of *Linepithema humile* stored in the British Natural History Museum (London), collected on the Madeira Island (Portugal) by Thomas V. Wollaston, *ca.*1850[19]. This is the first European occurrence of the Argentine ant, which predates even the type of specimens caught in Buenos Aires, in 1866 (Figure 1a)[20]. At least four decades passed, a time-lag ecologists identify in many processes of bioinvasion[21], between the ant's introduction and its detection by people. The first major cultural impact seems to have occurred only in the 1890s, when houses in Funchal, the major port town, were invaded by the Argentine ant in 1896, troubling the residents and scaring off many tourists. The same year also marked the first recorded damage in agricultural fields[22]. Municipal authorities tried unsuccessfully to exterminate the ants that invaded the city's gardens, at least since the early 1890s. Local newspapers mentioned the first drop in wine production and damage to several fruit trees caused by the ant's invasion[23].

Madeira had a prominent place in the transatlantic circulation for centuries which explains its position in the history of this bioinvasion. From the mid-1860s onwards, the transport of perishable goods, such as fruit and grain, was made essentially by steamships[24]. Funchal was also a place of rest and recovery for a (mostly British) foreign community that was convinced that the island was the best place to cure tuberculosis. There were regular navigation lines from England to Buenos Aires or Rio de Janeiro, and back, with Funchal and Lisbon as stopovers. It is likely that the Argentine ant arrived in Madeira as a stowaway in cargo ships, hidden in goods or in materials carried by migrants. Although to date, no-one can confirm its origin, the question allows for a speculative exercise informed by three non-mutually exclusive hypothesis, we will elaborate below: (1) Río de la Plata, Argentina, (2) Demerara, Guyana and (3) Brazil.

Figure 1 – Historical distribution of the Argentine ant in its European range by periods[25].



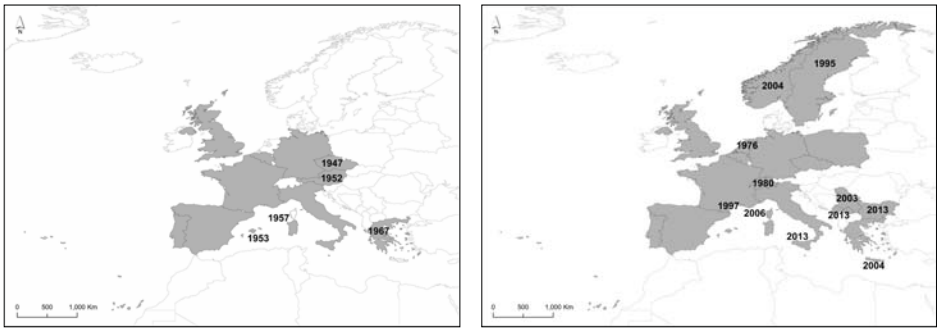
cont. →

a) Nineteenth century

b) 1900-1929

19 WETTERER *et al.*, 2006.
20 MAYR, 1868.
21 CROOKS & SOULÉ, 1999.
22 SCHMITZ, 1896.
23 *Diário de Notícias da Madeira*, August 7, 1896, 1 and September 4, 1896, 1.
24 LEITE, 1991.
25 The four maps reflect present time political geography and does not account for the historical changes in the countries boundaries.

Figure 1 – Historical distribution of the Argentine ant in its European range by periods (cont.).



c) 1930-1969 d) 1970-2014

Madeira wine was highly popular in the southern American territories, where it regularly arrived by vessel from the seventeenth century onwards. After Argentina became independent in 1816, the economy of Río de la Plata grew into one of the most open economies in the world[26]. For decades, Britain had a huge influence in the economic power of this South American country as it had in Madeira and in the Atlantic trade routes. Argentina exported agricultural goods, namely wheat and meat products, that Madeira lacked. These transactions were therefore mutually beneficial for both regions. Furthermore, imports of live ornamental plants and fruit trees that occurred during the nineteenth century could 'hide' these small specimens. Thus, the hypothesis of an accidental introduction from the native range is highly likely.

But other alternatives are mentioned in historical references. The priest Ernest Schmitz, who wrote the island's first inventory of ants, suggested other origins for the 'stowaways' of the Argentine ant that arrived in Madeira: «[a]nts were introduced recently from Demerara, or before from Brazil, where they are abundant, and a pest especially for naturalist collectors»[27]. Both locations were impacted by the economic and demographic globalization resulting from the Industrial Revolution. Hundreds of migrants from Madeira established themselves in the British Guyana. Portugal was undergoing a series of economic and political crises that were also impacting on the archipelago. Many young men took the opportunity to get out, to avoid compulsory military service in an age of turmoil (1807-51). They also escaped from endemic poverty and famine[28]. In addition, the sources of the most valuable agricultural productions and exports were being lost because of plant pests. The vines were destroyed by the *Odium tuckeri* (1852) and the phylloxera (1872). Sugarcanes suffered with the *Conyothyrium melasporum* (1884-86). In 1891, the Madeirans in the British Guyana reached a total of 12,166 (4.3 per cent of the population)[29]. Islanders found the opportunity to work in the sugarcane fields and,

26 PAOLERA & TAYLOR, 2003.
27 SCHMITZ, 1897.
28 MARQUES, 1976; NEPOMUCENO, 2006.
29 MENEZES, 2000.

sooner or later, used their experience to set up businesses in this fruitful transatlantic trade. In this way, they maintained a relationship with their origins and their customs. The hypothesis for the Guyanese origin of the Argentine ant specimens that invaded Madeira persisted in reference books[30], although there is no scientific evidence that the species ever occurred there[31].

But Schmitz's second hypothesis on the Brazilian origin of Argentine ants in Madeira was plausible at the time of Wollaston (c.1850). Well connected in the scientific community, he probably based his deductive thinking on a second-hand account of the situation in Brazil. On the other side of the ocean, these ants were causing damages outside their native range. Emilio A. Goeldi not only recognized them among other species that were plant pests but also noticed that they lived indoors, disturbing people's tranquillity and infesting their goods[32]. From the eighteenth century onwards, the carrying of cargo and passengers between South America (including Rio de Janeiro) and the North Atlantic (e.g. the Portuguese ports of Lisbon and Porto and, particularly by English ships, Southampton), used the Madeira Island as a preferred stopover[33]. While not ruling out Rio de la Plata as the origin of the Argentine ants living in Madeira, the Brazilian hypothesis seems equally plausible, since it was an urban pest in Rio de Janeiro (Brazil) at that time. The same origin was attributed to the ant population that invaded North American ports, where coffee ships from Brazil were docked, at the end of the nineteenth century[34].

The first records of this species on the European mainland are located in harbour towns (Lisbon and Porto) which regularly received traded products from the Atlantic routes, and which shared Madeira as a passage or loading point (of live plants and wine, for instance). In Mainland Portugal, its first occurrence dates back to 1889, when an invasion was detected in a Monastery near the harbour of Lisbon. But the species was not contained at that time and, a few years later, it invaded the whole town. In the late nineteenth century, the ant also occurred in the city of Porto[35]. A major exhibition was organised there in 1894, and live plants and objects were imported from the Portuguese overseas territories, including some from the Madeira Island. The neighbourhood around the exhibition site was infested. During this period, there is no evidence of the Argentine ant's presence in other regions in Europe. These early records support the hypothesis that the ant's introduction was associated with the maritime transport of people and goods.

30 SILVA & MENESES, 1921.
31 ROURA-PASCUAL *et al.*, 2004.
32 FOREL, 1895. The author mention Goeldi's observations on an attack of Iridomyrmex humilis to the wet ink in newspapers just printed.
33 GODINHO, 1953: 86; LEITE, 1991: 746 and 749.
34 WOODWORTH, 1908: 11.
35 MARTINS, 1907; SCHMITZ, 1896.

From 1900 to 1929

Harbours around the world were particularly vulnerable to the entry of the Argentine ant and the species appeared in several of the more relevant ports in the first decades of the twentieth century. This global travel and trade led the ant to the Mediterranean coastal areas (Spain, France, Italy and Sicily, Monaco and Bosnia), Northern Ireland, Scotland, England, Ireland, Belgium, Germany and Poland, as well as the Atlantic islands of Azores and the Canaries (Figure 1b). As such, the hypothesis that the harbour of Funchal had a role in the introduction and even cumulative population reinforcement of this species becomes plausible. Madeira's newspapers advertised regular shipping between the island and the main coastal cities of Great Britain, the Mediterranean ports, near the popular tourist beaches, and other ports in northern Europe, as well as regular travels to and from Brazil and Argentina, mooring in the Canary Islands and connecting the Mediterranean cities of Genoa and Naples[36].

Early in the twentieth century, the Argentine ant occurred in large numbers in Belfast (1900) and in the harbour of Hamburg (1901). In 1927, H. Donisthorpe stated that the ant could be found in 11 locations in the UK, including Guernsey (1919), Edinburgh (1912), Enfield (1916), Eastbourne (1916, where two streets were «uninhabitable on account of the presence of this species»), Broadbottom (1921), near Manchester (1921), Fallowfield (1922), Plymouth (1923) and Hertfordshire (1926)[37]. The Argentine ant also occurred in the Windsor Forest and District (1927)[38].

These data confirmed its ability to survive under the cool temperate and moist regions of Britain, whether protected indoors or not. Some newspapers provided reports of the scientific notes published on the Argentine ant[39]. Others fuelled public fear, fabricating or exaggerating facts, telling stories about ants «that had been known to eat a baby», that were «swarming over the breakfast table» in British houses since «1918», or that «virtually killed off the bird life» in the Madeira Island[40]. As early as 1911, the British press echoed news about the Argentine ant's invasion in California, talking about a 'campaign against ants' and highlighting the damages the species caused in agriculture[41].

In this period the Argentine ant occurred in a few places away from the coast. Its occurrence in the suburbs of London showed how far inland the species had progressed, hidden in goods or live plants, travelling across the territory. The Argentine ants found in the suburbs of Manchester (Fallowfield, in 1922), inside boxes of imported Canary bananas, are an example of a combined way of spreading, since they had to undergo maritime transport, by ship, and land transport, possibly by railway. Secondary introductions allowed the ants to establish even in areas where climate conditions were unfavourable.

36 *Diário de Notícias da Madeira*, January 10, 1910, 4.
37 DONISTHORPE, 1927.
38 DONISTHORPE, 1930.
39 *Western Morning News*, May 11, 1922, 3.
40 *Taunton Courier, and Western Advertiser*, March 8, 1922, 8.
41 *Walsall Advertiser*, May 6, 1911, 8.

The Argentine ant's plasticity and ability to colonise artificial environments allowed its naturalisation even when subjected to the most adverse weather.

In the 1920s, Cannes and Tamaris (France) faced an ant's occurrence in extremely high numbers[42]. Their inhabitants had experienced other bouts of ants caused by native species, but they did not realise immediately that this was a different invasion. The entomologist L. Chopard suggested that the two outbreaks *loci* were formed independently from each other, from live plants imported for ornamental arrangements. Furthermore, he described their major impacts: (1) relevant economic damages as a plant pest in citrus orchards, fig, cherry and pear trees, and possibly in vineyards, due to the interaction it develops with mealy bugs, scale insects and aphides; (2) in houses, «only the habitants of the invaded homes can know how much the ant is unbearable and how its damage exceeds those of native species, even of the most abundant»; (3) despite the fact that there were no records of human attacks, a paediatric hospital was evacuated, as a result of the invasion. The French national press also echoed this report. The newspaper *Le Temps* mentioned the «invasion» that occurred in Cannes during the «winter» with «ants that came from California»[43]. The French entomologist also stated that the Argentine ant invasion in the French Riviera resulted from the maritime trade and travel and land transportation – both railway and road. Due to tourism, since the nineteenth century, a variety of products were imported for consumption in the region, including live plants for ornamental purposes. Tamaris and Cannes are in the vicinity of Toulon and Nice, respectively, and are not far from the major ports of Marseille and Genoa.

True scourges also affected Italian communities, which triggered a response from the official authorities. Due to the extremely serious situation lived in Liguria di Ponente, Guido Paoli published a leaflet about the pest[44]. He would become well known in the following two decades for his support to the fight against the ants in San Remo and for being the director of the *Osservatorio Fitopatologico de Chiavari*. The Argentine ant had an impact on several provinces, including Rome. Researchers made every effort to advise farmers and to report the results of the first eradication attempts[45]. Following the Royal Decree-Law on fighting the Argentine ant (1st July 1926), the prefects of the Italian provinces had to assume their responsibilities in conducting the control process. Given the damage caused, the whole country was mobilised. The prefect of Trento set up an early warning system, alerting citizens to «the danger that a tiny exotic ant recently imported into Italy could represent if introduced in our province». Furthermore, the notice requested anyone who detected ants to inform the prefecture and to deliver some specimens to the phytopathology services in town so as to receive advice on the most appropriate remedies or procedures. Meanwhile, despite the insecticide applications in infested areas, the ant invasion did not stop[46].

42 CHOPARD, 1921.
43 *Le Temps*, Décembre 29, 1921, 2.
44 PAOLI, 1923a.
45 PAOLI, 1922a; PAOLI, 1922b; PAOLI, 1923b; SERI, 1923.
46 PERFETTO DI TRENTO, 1926.

Phytosanitary measures were also taken in Portugal and Spain. In Madeira, in 1903, the local press suggested a product based on benzene («Lyzol») and plaster to help prevent the ants from invading the trees[47]. Among other methods, arsenic poisoning – suggested by the American entomologists in the previous decade – was widely used in the Mediterranean area[48]. In the region of Valencia (Spain), where the species was also considered «one of the most fearsome ants known for their invasiveness and the damage it causes in orchards and in the cities», people preferred alcohol and benzene, fearing the negative impact of deadly toxins on bees[49].

Despite the naturalists' warnings, the promotion of exotic plant gardens, originating from different parts of the world, led to a further dispersal of the species, in the beginning of the twentieth century, to places far from the Mediterranean and Atlantic ports, where it had already been introduced. Such was the case in Belgium, German Silesia and Bosnia.

From 1930 to 1969

During this period there were new recorded invasions in the Mediterranean region (Malta, the Balearic Islands and Corsica) and the species was detected in the Czech and Austrian territories. There are no references to this species in Ireland, Poland or Bosnia, countries in which its locations were restricted to greenhouses and botanical gardens in the previous period. At this time, however, the Argentine ant was established in 12 countries (Figure 1c).

A small article published in a political satirical newspaper of Buenos Aires (Argentina) reported the Argentine ant invasion in Europe. It gave an account of the social and political repercussions of the invasion at a transcontinental range[50]. According to the entomologist Angel Gallardo, Europe would have to use two subjects to demean Argentina: the ant invasion and the Creole tango. He denied that the invasive ant was from Argentina: «I conclude that it must not be a native of the country because it is sensitive to the cold and lives only indoors, in kitchens and in every heated place. It is easy to understand that if it is American, it comes from the warmer areas of our continent. It has probably come from Brazil transported in bundles of merchandise». He denoted that ants in Argentina had been in urban areas since long ago and mentioned two methods used to control them: a popular repellent made of *caracú*[51] bone and arsenic traps, which Gallardo recommended.

National authorities and private entities made every effort to control the outbreaks with maximum efficiency because it continued to cause serious damage in agriculture. Sometimes authorities neglected the potential environmental risks of using poisons. However, the denial of any risks in the discourse of the advertisements in local newspa-

47 *Diário de Notícias da Madeira*, September 30, 1903, 2.
48 NEWELL & BARBER, 1913.
49 FONT DE MORA, 1923.
50 *Caras y caretas*, July 15, 1933, 18.
51 *Caracú* is a cattle breed common in South American countries.

pers is of no surprise. In the newspaper *Jornal da Madeira*, the insecticide «FLIT» presented itself as the «ruthless destroyer of all home insects and parasites», stating that it was so harmless that its smell would be considered «pleasant for many people»[52]. Produced by the Standard Oil Company, FLIT contained 5% of the now known dangerous *DDT*. Another newspaper from Madeira advertised the «TANGLEFOOT», a product with «excellent quality and unsurpassed results». Advertisements even promised a considerable amount of money to anyone who could prove that it «was harmful to human health and pets»[53]. The product created sticky barriers, where insects became trapped – the action was strictly mechanical.

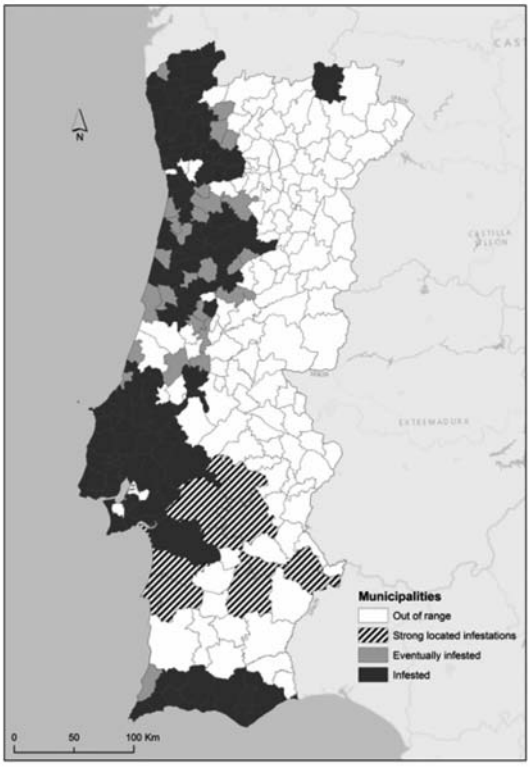
On 7 October 1948, the Commission of Agriculture and Food of the Italian Senate discussed the allocation of a significant amount of funds[54] to continue the fight against the Argentine ant in the provinces of Imperia, Savona, Rome, Latina, Napoli, Reggio Calabria, Messina and Palermo[55]. The rapporteur made the case by vehemently enumerating its impacts: «it penetrates flowers to collect nectar and sometimes destroys stamens and pistils; it sucks the fruit's pulp from the slightest damage; it goes into hen houses and rabbit holes (…); it seeps into homes through any minimum slot; (…) it disturbs people during sleep, especially the old, the sick and the children; houses invaded may become uninhabitable». He also suggested that the old arsenic poison should be replaced by more modern and effective formulas: «[r]ecently, they have employed with greater success new methods of fighting by means of venom, especially D.D.T. and the *gammaesano*[56] powder, scattered over the anthills and in places frequented by ants. (…) These means seem most advisable than the poisoned syrups, because they are more rapid and convenient to use, and because they do not subtract useful substances to human nutrition, such as sugar and honey».

In 1951, the species was a major concern in mainland Portugal. A census, commissioned by municipalities, was conducted by a student of agronomy for the plant pathology official body[57]. Of the 272 Portuguese municipalities, the invasion of the Argentine ant was confirmed in 123, 12 of which had «strong infestations located in restricted areas, particularly in citrus orchards» and 27 that were «probably infested but about which it was not possible to obtain more information» (Figure 2). The southern and western coastal bands were «infested»; in the south, both on the coast and inland, the localised presence of the species appeared to be associated with crop losses, which represented a relevant part of the income of small and medium landowners.

52 *Jornal da Madeira*, June 22, 1930, 3.
53 *Diário de Notícias da Madeira*, August 8, 1930, 8.
54 ITL 200 millions, corresponding to $320,000 on that date, according to the official exchange rate that had been established in 1949 by the system «Breton Woods» and remained stable until 1968 (MCNAMARA, 1998: 72-75); in 2016, the comparable amount is $3,148,361.83 (*Measuring Worth – Relative Worth Comparators and Data Sets. Measuring Worth*. [accessed 24 May 2016] at <URL https://www.measuringworth.com/>).
55 SENATO DELLA REPUBLICA ITALIANA, 1948.
56 Trade name of the gamma isomer of the esacloro-cyclohexane, powerful synthesis insecticide that is obtained by chlorination of benzene.
57 DIAS, 1952.

In 1954, Portuguese authorities reported the occurrence to the European and Mediterranean Plant Protection Organization (EPPO). The Decree no. 17577 (8th November 1929), defined compulsory control measures and punitive regime in the case of refusal or negligence in fighting the invasive insect, but it had little to no effect in the mitigation of the pest. At the time, «the control of this insect was done on a more voluntary basis but in view of the success of the control measures adopted, and since everyone understands the need to combat the pest, the ant has ceased to have as much importance as in the past»[58]. This was wishful thinking and no one could match it with reality. The authorities continued to promote awareness campaigns to fight the Argentine ant and tried new organochloride insecticides (including the DDT)[59]. Damages caused in citrus orchards and other fruit trees (such as fig trees and vines) were the reason behind these campaigns; however, the brochures and booklets did not reflect a concern over the possible contamination of soil and water or the destruction of other native species.

Figure 2 – The Argentine ant distribution on mainland Portugal in 1951.



58 EPPO – *EPPO reporting*, Nov 1954. 1954 [accessed 24 August 2015] at <URL http://archives.eppo.int/EPPOReporting/1954/Rse-54-11.pdf>. Founded in 1951, the EPPO took note of the national reports sent by its members and developed international strategies against the introduction and spread of dangerous pests and to promote safe and effective control methods.
59 PINTO-GANHÃO, 1958; REPARTIÇÃO DE SERVIÇOS FITOPATOLÓGICOS, 1950.

In France, the same 1954 EPPO report noted the occurrence of the Argentine ant in the departments of Var and Alpes-Maritimes (Mediterranean zone), where it was considered «[e]xtremely harmful to stored foodstuffs, bee hives and young animals (rabbits, pigeons)». In Italy, the report mentioned that it «[i]s found in only a few areas, so far quite locally, but where appreciable damage is caused (in Liguria, Lazio, Campania, Calabria and Sicily) (…) [t]he insect attacks crops and stored foodstuffs in warehouses and dwelling houses». The Mediterranean region continued to face the same pest it had endured in the beginning of the twentieth century.

In the same report, the United Kingdom authorities also expressed their unease. There had been two occurrences, both indoors: one in a hospital in Kent, and the other in greenhouses in Berkshire. The Infestation Control Division of the Ministry of Agriculture had been concerned with the treatment of the latter, and they believed they had been successful in eradicating the ant.

The ease with which people and goods travelled using railways and roads were complemented and extended by the mobility of maritime travels in this period, shortening distances and countering the isolation of regions on the national level and among European nations.

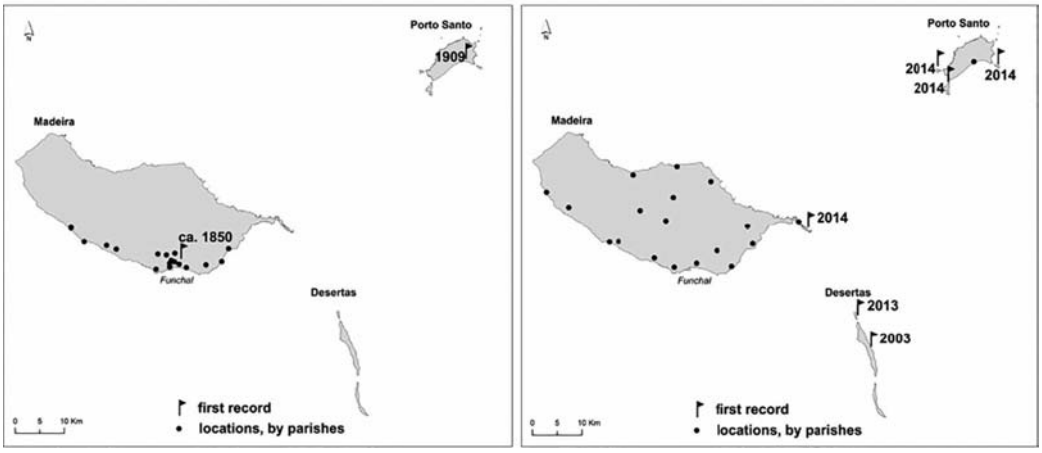
From 1970 to 2014

In this period, almost all the Mediterranean countries reported the Argentine ant as invasive and harmful to the local endemics (Figure 1d)[60]. In Mediterranean and Macaronesian archipelagos, the species invaded the islands and islets, occupying all the onshore portions of land, which confirms the continuous role played by sea transportation, now combined with other means. Protected areas for nature conservation in Portugal, France, Italy and Greece were included in the list of invaded territories. In the Canary Islands, where the species had been known since 1910, it was detected in Fuerteventura in 1992[61]. With this last record, the species reached full local distribution. In the Balearic Islands, where the species had been known since 1953, the Argentine ant expanded from Soller to the whole island of Mallorca[62]. The case of the Argentine ant on the Madeira archipelago is an additional example of how this species dispersed to all the territories (islands and islets) where it found a way to become invasive (Figure 3). The first records of invasion suggested that the ant had a coastal distribution in the island of Madeira, being abundant in Funchal and its surroundings, and also in other areas of the southern coast. However, the species was rare in the east and northern coast of the island[63]. In 1909, the ant was detected in Porto Santo. In 1937, the Argentine ant occurred in Madeira supposedly below the altitude of 500 meters[64]. Throughout the twentieth century, the agricul-

60 BERVILLE *et al.*, 2012.
61 ESPADALER & BERNAL, 2003.
62 GOMÉZ & ESPALADER, 2005.
63 SCHMITZ, 1896.
64 SARMENTO, 1937.

ture official services promoted and executed repeated control measures, mainly in Funchal and in the south coast parishes[65]. In the 1990s, researchers looked for its range and its impacts on biodiversity, sampling urban sites, agricultural fields and natural habitats[66]. By doing this, they recorded the species in several places of Madeira, namely along the northern coast, near the airport, and in the mountain areas, such as in Curral das Freiras, a deep valley far from the coast. The Argentine ant was also recorded in several places of Porto Santo, including near the airport, and in huge numbers in Desertas (2003 and 2013), as well as in the islets of Ilhéu do Desembarcadouro (2014, near Madeira), Ilhéu do Ferro, Ilhéu do Farol, Ilheú de Cima and Ilhéu da Cal (2014, near Porto Santo), which are uninhabited places and legally protected nature reserves, however, yachts and other recreational boats still approach the islets today.

Figure 3 – Historical range of the invasive Argentine Ant in Madeira archipelago.



a) before 1970

b) from 1970 onwards

On the European mainland, the spread was not restricted to mild winter areas. Its range extended to the north, comprising new countries such as the Netherlands, Switzerland, Sweden and Norway. Eastern countries, such as Bulgaria, Montenegro, Serbia and Kosovo, also had their first record during this period and, despite the lack of data for the period of 1930 to 1969, the Argentine ant is again referenced in Poland.

Due to its capability to proliferate in natural and humanised habitats (e.g. degraded areas, urban environments and agricultural fields), this species remains a main source of concern – expressed periodically in years of population explosion. In 2009, a newspaper published the testimony of an inhabitant of the neighbourhood *Croix-Daurade,* near the city centre of Toulouse (France mainland): «[i]t's been three weeks since Argentine ants

65 SERVIÇOS ENTOMOLÓGICOS E PATOLÓGICOS, 1929.
66 AAVV, 2014; WETTERER *et al.*, 2007.

have invaded my kitchen and entrance. They have covered every angle of my house to reach the pantry. I have to empty the pantry and clean it regularly, otherwise it's madness. I also have them all around my house»[67].This kind of report is relatively common in the press and on internet pages, although the invasive species has not always been properly identified.

The last third of the twentieth century brought about a new era of global circulation of people and goods by sea, land and air. At the same time, there were changes in consumption habits. A single world market, with an economy dominated by imports and exports, made the goods purchased in any European country a mirror of the economic geography of the planet. Fresh produce (e.g. fruits, vegetables and live plants) became accessible throughout the whole year, due to fast shipping and the methods available to preserve them. Non-wanted organisms continued to travel across the world, hidden in goods and other merchandise.

Now, people travel the world for personal and professional reasons as they never did before. The species arrival to Norway is an illustrative example of how the global circulation of people and goods generated new opportunities for the dispersal of organisms, multiplying the possibilities of a successful introduction. The species was first seen in two flats above a stable in 2004 and soon the number of ants became unbearable. The dwellers had recently been visiting Spain and Italy with their horses and the ants had been observed in the trailer transporting the horses, upon their return to Norway[68]. Although there is no indication that the Argentine ant may have spread to outdoor habitats in Norway, the introduction and long duration of its infestation could become a cause for concern in the event of a future climate change, which could create conditions more suitable for this tolerant sub-tropical species.

Airports and maritime ports are identified as potential points of entry for invasive ants. In France, a study on ant invasions using modelling techniques shows that «the ports of entry with the highest suitability» were located in the South: Biarritz, Toulon and Nice[69]. The risks of future outbreaks of the Argentine ant cannot be ruled out in southern regions and in places where it still proliferates merely indoors. This justifies the social fear over a process that began a long time ago but whose impact may persist or even worsen in the future.

Archipelagos are good models for the understanding of the continuous spread and recent colonisation of the Argentine ant in areas adjacent to those previously invaded, as mentioned above regarding Madeira. There, planes and private boats played a significant role in the first arrival and in the second introduction, either between islands and islets from the same archipelago or from other foreign origins. Only genetic studies or aggression tests could clarify this issue. Biology is crucial for the understanding of the spread of the Argentine ant and its interpretation in relation to the social phenomena that are

67 GOUTY, 2009.
68 GÓMEZ *et al.*, 2005: 63-64.
69 GÓMEZ *et al.*, 2005.

behind it. On Palma de Mallorca, in the Balearic Islands, not all introduced ants belong to the same gene pool[70]. At least two introductions have occurred in two different times[71].

Concurrently with the expansion and strengthening of the population, the species may also become temporarily undetectable in some places, or may even disappear. There are no records attesting that the situation results from successful control or eradication measures. But the absence of a record in Ireland from 1930 to 2014 may lead to the conclusion that the environmental conditions in the country are unfavourable for the Argentine ant to settle and/or spread after arrival. Likewise, Bosnia has no known records after the two first decades of the twentieth century, despite the ant's occurrence in the neighbouring territories of Croatia, Serbia and Montenegro.

LESSONS FROM HISTORY: LOOKING TOWARDS THE FUTURE

The Argentine ant's spread across Europe cannot be explained by a natural widening of the range, successively added by coalescent areas. Environmental history is a field inherently interdisciplinary, useful in the understanding of the complexity of the natural and cultural dimensions inherent to the introduction processes and the subsequent invasions, wherever they occur. This species has been transported by human agency to new geographic regions through three different pathways: transport by sea, land and air. These are all relevant today, but historically, they prevailed in different ways.

Between the fifteenth and eighteenth centuries, the ant occurred in Portugal and Spain, due to their early voyages (Atlantic islands, the coast of Africa and the Orient, the Americas), in France, the Netherlands and Great Britain, through their commercial fleet travels across oceans, and colonised remote territories around the globe[72]. In the second half of the nineteenth century, the sailing ships and the new steamships were competitors in cargo and passenger transportation. However, the steamship began to prevail because it connected the main harbour cities in a safer, faster and more regular way[73]. In Europe, the expansion of the railway network was unequal. England witnessed a major stimulus in the 1830s and 1840s, on the other hand, the railway in France rose steadily from approximately 1840 to 1880. However, on the periphery of Europe, the process was much slower. In Portugal, for instance, the first line, with 36 km, only opened in 1856. By then, «England had more than 10,000 km of tracks; France had almost 6,000 km»[74]. Railways dominated communications by land until 1930, when they «were approaching saturation in all industrial countries». Nevertheless, regarding long travels, planes only exceeded the cargo and passenger capacity of the railway in the 1970s, meanwhile, the car and bus became the favourite means of transportation for short and medium distances, in Europe[75]. All these

70 TUCCI COLACE & ESPALADER, 2013.
71 GÓMEZ & ESPADALER, 2005.
72 BERNSTEIN, 2008; NEWITT, 2005; BAILYN, 2005; GREENE & MORGAN, 2009.
73 HARLEY, 1971.
74 SCHWARTZ *et al.*, 2011; SILVEIRA *et al.* 2011.
75 GRÜBLER, 2003.

processes surpassed physical barriers, until then deemed unbridgeable, as well as the capabilities for biological dispersion.

The history of transportation plays an important role in the economic history research and its technology has been studied in all geographies and different time periods[76]. In general, research shows that, as population, prosperity and rates of technological change rise through time, so does the use of human transport, by land, sea or air. Throughout the periods comprised in the scope of this article, people have increasingly travelled for long distances, carrying both personal and commercial products for export and import. The cargo transportation also grew to levels that would seem impossible a few decades ago, making the global trade a feature of today's world.

The accidental introductions of organisms, such as ants, and the transportation history are closely linked. The transport of alien species is taken into account when describing the ecological effects of modern aviation, for it provides ideal opportunities for the rapid dissemination of species which often become pests of agriculture, horticulture and forestry, leading to huge economic losses and the dissemination of infectious disease agents to all the major cities of the world, within a very short time[77]. Therefore, leisure and business travels are being targeted by organisations such as the EPPO, responsible for the campaign «Help us to protect our crops and beautiful countryside against plant pests and diseases»[78]. The risk of accidently introducing harmful organisms is higher if plants, seeds, fruits, vegetables or flowers are carried in the luggage. Travel and trade are then the focal points of a prevention strategy that might limit human action. The inspection and certification of commercial commodities are common procedures in present times, but surveillance is not fully achievable at the level of personal belongings.

Biosecurity policy has been quite ineffective in many countries[79] but integrated strategies are needed to stop the escalating impacts of bio-invaders in the economy (resulting from direct damages and mitigation costs) and in biodiversity. Regardless of their success or failure, the past attempts to prevent introductions or control unwanted animals and plants provided the necessary knowledge to assess the feasibility of the measures that are currently being undertaken. The past human agency in the spread of bio-invaders serves as a warning against underestimating nature, providing valuable lessons on risk awareness and on how to properly respond to early warning signs. Without a new focus on preventing unintentional transfers, small and uncharismatic organisms may become a scourge. Integrative economic analysis and policy, filling information gaps, and facilitating the globalization of information, are three areas that need greater attention in order to prevent, or respond to biological invasions[80].

76 For example, existent studies on railways by GOURVISH, 1980 (Britain 1830-1914), REES, 1995 (Soviet Union, 1928-41), KERR, 2006 (India, 1853-2005), and ESPINHA DA SILVEIRA *et al.* (Portugal, 1801-1930).
77 KELLY & ALLAN, 2006.
78 *European and Mediterranean Plant Protection Organization* (EPPO). [accessed 26 May 2016] at <URL https://www.eppo.int/>.
79 SCALERA *et al.*, 2012.
80 MEYERSON & MOONEY, 2007.

The historical narrative of the Argentine ant invasion in Europe shows that this organism was only detected when their numbers were already very high and the damage was already being felt. Eradication was then unfeasible and all efforts were futile, for the extermination required the destruction of all the hidden nests of the colony. Recognized as harmful on local, regional and national levels, the Argentine ant has been the subject of severe legislative measures and expensive control or eradicating campaigns, which have been unsuccessful. Failures can be partially attributed to the methods used in attempts to wipe out the pest. Non-coordinated and narrow scale action never eliminated the species, either because the destruction of the breeding spots was inefficient (killing millions of worker ants does not prevent reproductive colonial activity ensured by queens) or because taking action without coordinated measures in the adjacent areas made the effort useless in the medium and long term. But even today, when the species seems to be «naturalized» everywhere, each time a local population explodes, the damages and nuisances are felt once again. As other «tramp-species», its history can be used to encourage society to care about the consequences of a globalized natural world.

La Maitre's claim neatly summarizes the increasing number of bioinvasions around the world: «[h]umans are both the cause of invasions and, potentially, the solution to the problem»[81]. That is why, by combining the natural and cultural dimension, the histories of bioinvasions contribute to the understanding of the complex and multifaceted problem of circulating organisms, providing an insight on the different stages of the invasion process, from importation to introduction, establishment and spread.

BIBLIOGRAPHY

AAVV (2014) – *LIFE Ilhéus de Porto Santo – Progress report (from 31/10/2013 to 31/10/2014)*. Funchal: Serviço do Parque Natural da Madeira.

BAILYN, Bernard (2005) – *Atlantic History: Concepts and Contours*. Harvard: Harvard University Press.

BARONI URBANI, Cesare (1968) – *Studi sulla mirmecofauna d'Italia. IV. La fauna mirmecologica delle isole Maltesi ed il suo signifi-cato ecologico e biogeografico*. «Annali del Museo Civico di Storia Naturale», 77, p. 408-559.

BERNARD, F. (1956) – *Remarques sur le peuplement des Baléares en fourmis*. «Bull. Soc. Hist. Nat. Afr. Nord», Vol. 47, n.º 4, p. 254-266.

_____ (1960) – *Fourmis recoltées en corse par J. Bonfils (1957)*. «Compte rendu sommaire des sceances de la societé de biogeographie», Vol. 36, p. 108-114.

_____ (1968) – *Faune de l'Europe et du Bassin Méditerranéen. 3. Les fourmis (Hymenoptera Formicidae) d'Europe oc-cidentale et septentrionale*. Paris: Masson.

BERNSTEIN, William J. (2008) – *A Splendid Exchange. How Trade Shaped the World*. New York: Grove Press.

BERVILLE, Laurence (2013) – *La fourmi d'Argentine (Linepithema humile) face à une fourmi dominante du genre Tapinoma en milieu insulaire*. Aix-Marseille Université.

BERVILLE, Laurence; RENUCCI, Marielle; PROVOST, Erick (2012) – *Mise en place de protocoles de contrôle de la fourmi d'Argentine sur les îles de Port-Cros et de Porquerolles (Var, France)*. «Scientific Reports Port-Cros National Park», Vol. 26, p. 91-108.

81 LE MAITRE *et al.*, 2004.

BLANCK, A. (1949) – *La fourmi d'Argentine dans le Sud Est de la France*. «Phytoma – Revue de Phytomedicine Appliquée».

BLANC, Sylvie (2006) – *Hétérogéinité chimique dans une homogénéité genétique et comportamentale putative chez Linepithema humile*. Aix–Marseille Université.

BOER, Peter; VIERBERGEN, Bert (2008) – *Exotic ants in The Netherlands (Hymenoptera: Formicidae)*. «Entomologische Berichten», Vol. 68, n.º 2, p. 121-129.

BODENHAMER, David J. (2008) – *History and GIS: Implications for the Discipline*. In KNOWLES, Anne Kelly; HILLIER, Amy, *ed.* – *Placing history: how maps, spatial data, and GIS are changing historical scholarship*. Redlands: ESRI, Inc., p. 220-231.

BONDROIT, J. (1911) – *Fourmis exotiques importées au jardin botanique de Bruxelles*. «Annales de la Société Entomologique de Belgique», Vol. 55, p. 14.

BRAA, Dean M. (1997) – *The Great Potato Famine and the Transformation of Irish Peasant Society*. «Science & Society», Vol. 61, n.º 2, p. 193-215.

CASEVITZ − WEULERSSE, J. (1974) – *Ants collected in Corsica and in Sardinia*. «Annales de la Societé entomologique de France», Vol. 10, p. 611-621.

Caras y caretas, 1933.

CARPENTER, G. H. (1902) – *Household insects. A tropical black ant. Iridomyrmex humilis, Mayr*. «Economic Proceedings of the Royal Dublin Society», Vol. 1, p. 155-157.

CHOPARD, L. (1921) – *La fourmi d'Argentine Iridomyrmex humilis var. arrogans Santschi dans le midi de la France*. «Annales des Épiphytie», Vol. 7, p. 237-265.

CORIN, Steve E.; LESTER, Phillip J.; ABBOTT, Kirsti L.; RITCHIE, Peter A. (2007) – *Inferring historical introduction pathways with mitochondrial DNA: the case of introduced Argentine ants (Linepithema humile) into New Zealand*. «Diversity and Distributions», Vol. 13, n.º 5, p. 510-518.

CROOKS, Jeffrey A. and SOULÉ, Michael E. (1999) – *Lag times in population explosions of invasive species: causes and implications*. In SANDLUND, Odd Terje; SCHEI, Peter Johan; VIKEN, Åslaug, *eds*. – *Invasive Species and Biodiversity Management*. *Dordrecht*: Kluwer Academic Press, p. 103-125.

CROSBY, Alfred W. (2004) – *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*. Cambridge: Cambridge University Press.

DAISIE – Species Factsheet (2015) – *Delivering Alien Invasive Species Inventories for Europe*. [accessed 24 August 2015] at <URL http://www.europe-aliens.org/speciesFactsheet.do?speciesId=51083>.

Diário de Notícias da Madeira. 1896, 1903, 1910 and 1930.

DIAS, J. C. Silva (1952) – *A formiga argentina Iridomyrmex humilis Mayr. Elementos para o seu estudo em Portugal.* Lisboa: ISA, Universidade Técnica de Lisboa.

DIAZ BUITRAGO, Mireia (2012) – *Ecological and Biological strategies taken by the argentine Ant, Linepithema humile (Mayr, 1868), in cold seasons. Effects of winter nests management in natural invaded areas*. Girona: Univ. Girona.

DONISTHORPE, H. (1927) – *The ants (Formicidae), and some myrmecophiles, of Sicily*. «Entomological Record and Journal of Variation», Vol. 39, p. 6-9.

____ (1930) – *The ants (Formicidae) and guest (myrmecophiles) of Windsor Forest and District [part]*. «Entomological Record and Journal of Variation», Vol. 42, p. 13-16.

DOUWES, P. (1995) – *Sveriges myror*. «Entomologisk Tidskrift», Vol. 116, p. 83-99.

EPPO (1954) – *EPPO reporting, Nov 1954*. [accessed 24 August 2015] at <URL http://archives.eppo.int/EPPOReporting/1954/Rse-54-11.pdf>.

____ (2016) – *European and Mediterranean Plant Protection Organization (EPPO)*. [accessed 26 May 2016] at <URL https://www.eppo.int/>.

ESPADALER, Xavier (1997) – *Catàleg de les formigues (Hymenoptera: formicidae) dels Països Catalans*. «Sessió Conjunta d'Entomologia», Vol. IX, p. 23-42.

ESPADALER, Xavier; BERNAL, Víctor (2003) – *Exotic ants in the Canary Islands (Hymenoptera, Formicidae)*. «Vieraea», Vol. 31, p. 1-7.

FERRÃO, José E. Mendes (1992) – *A aventura das plantas e os descobrimentos portugueses*. Lisboa: Instituto de Investigação Científica Tropical.

FONT DE MORA, R. (1923) – *Sobre la presencia de la hormiga argentina (Irido…) en Valencia*. «Boletin de la Real Sociedad de Espanola de Historia Natural», Vol. 23, p. 77-78.

FOREL, Auguste (1895) – *A Fauna das Formigas do Brazil*. Para-Brazil: Tipografia de Alfredo Silva Lda.

FRISQUE, K. (1935) – *La fourmi d' Argentine, Iridomyrmex humilis Mayr dans les serres de Belgique*. «Bull. Ann. Soc. Entomol. Belg.», Vol. 75, p. 148-153.

FRAWLEY, Jodi; MCCALMAN, Iain (2014) – *Invasion ecologies: the nature/culture challenge*. In FRAWLEY, Jodi; MCCALMAN, Iain, *ed.* – *Rethinking Invasion Ecologies from the Environmental Humanities*. London: Routledge, p. 3-14.

GODINHO, Vitorino de Magalhães (1953) – *Portugal, as frotas do açúcar e as frotas do ouro (1670-1770)*. «Revista de História», Vol. 7, n.º 15, p. 69-88.

GÓMEZ, Crisanto; ROURA-PASCUAL, Núria; BIRKEMOE, Tone (2005) – *Argentine ants Linepithema humile (Mayr, 1868b) infesting Norwegian flats*. «Norw. J. Entomol.», Vol. 52, n.º 1, p. 63-64.

GOMÉZ, K.; ESPALADER, Xavier (2005) – *La hormiga argentina (Linepithema humile) en las Islas Baleares*. Conselleria de Medi Ambient. Govern de les Illes Balears.

GOURVISH, T. R. (1980) – *Railways and the British Economy, 1839-1914.* London: Macmillan Education UK.

GOUTY, Elodie (2009) – *La fourmi d'Argentine envahit Toulouse*. In *LADEPECHE.fr*. [accessed 24 August 2015] at <URL http://www.ladepeche.fr/article/2009/06/19/626599-la-fourmi-d-argentine-envahit--toulouse.html>.

GREENE, Jack P.; MORGAN, Philip D., *ed.* (2009) – *Atlantic History: a Critical Appraisal*. New York: Oxford University Press.

GROVE, Richard H. (1996) – *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860.* Cambridge: Cambridge University Press.

GRÜBLER, Arnulf (2003) – *Technology and Global Change*. Cambridge: Cambridge University Press, 2003.

Identification guides and checklists of plants and animals. Discover Life [accessed 24 August 2015] at <URL http://www.discoverlife.org/mp/20q>.

Jornal da Madeira, 1930.

HARLEY, Charles K. (1971) − *The shift from sailing ships to steamships, 1850-1890: a study in technological change and its diffusion*. In MCCLOSKEY, Deirdre N., *ed.* – *Essays on a Mature Economy: Britain after 1840*. Princeton: Princeton University Press, 1971, p. 215-238.

HOLZEL, E. (1966) − *Hymenoptera-Heterogyna: Formicidae*. «Catalogus Faunae Austriae», Vol. 16, p. 1-12.

KELLER, Reuben P.; CADOTTE, Marc W.; SANDIFORD, Glenn (2014) – *Working across disciplines to understand and manage invasive species*. In KELLER, Reuben P.; CADOTTE, Marc W.; SANDIFORD, Glenn, *ed.* – *Invasive Species in a Globalized World. Ecological, Social, and Legal Perspectives on Policy*. Chicago: The University of Chicago Press, p. 1-20.

KELLY, Tom; ALLAN, John (2006) − *Ecological effects of aviation*. In DAVENPORT, John; DAVENPORT, Julia L., *ed.* – *The Ecology of Transportation: Managing Mobility for the Environment*. Dordrecht: Springer, p. 5-24

KUTTER, H. (1981) – *Iridomyrmex humilis Mayr (Hym., Formicidae), Gattung und Art neu für die Schweiz*. «Mitteilungen der Schweizerischen Entomologischen Gesellschaft», Vol. 54, p. 171-172.

LE MAITRE, David C.; RICHARDSON, David M.; CHAPMAN, R. Arthur (2004) – *Alien plant invasions in South Africa: driving forces and the human dimension*. «South African Journal of Science», Vol. 100, n. 1, p. 103-112.

Le Temps, 1921.

LEITE, Joaquim da Costa (1991) – *O transporte de emigrantes: da vela ao vapor na rota do Brasil, 1851-1914*. «Análise Social», Vol. XXVI, n.º 112/113, p. 741-752.

Linepithema humile. 100 of the World's Worst Invasive Alien Species. Global Invasive Species Database. 2005 [accessed 1 February 2016] at <URL http://www.issg.org/database/species/search.asp?st=100ss>.

MARQUES, A. H. de Oliveira (1976) – *History of Portugal*. New York: Columbia University Press, Vol. 2.

MARTINS, Conceição Andrade (1991) – *A filoxera na viticultura nacional*. «Análise Social», Vol. 26, n.º 112/ /113, p. 653-688.

MARTINS, M. N. (1907) – *A formiga-ladra (Iridomyrmex humilis Mayr)*. «Broteria», Vol. 6, p. 111-119.

MAYR, Gustav (1868) – *Formicidee novae Americana*. «Annuario della Societá Naturalista Modena», Vol. 3, p. 164.

MCNAMARA, Kathleen R. (1998) – *The Currency of Ideas: Monetary Politics in the European Union*. Cornell University Press.

MCNEILL, William H. (1976) – *Plagues and Peoples*. New York: Anchor.

Measuring Worth – Relative Worth Comparators and Data Sets. Measuring Worth [accessed 24 May 2016] at <URL https://www.measuringworth.com/>.

MENEZES, M. Noel (2000) – *Some preliminary thoughts on Portuguese emigration from Madeira to British Guiana. Guyana News and Information*. [accessed 1 September 2015] at <URL http://www.guyana.org/ special/portuguese.html>.

MEYERSON, Laura A.; MOONEY, Harold A. (2007) – *Invasive alien species in an era of globalization*. «Frontiers in Ecology and the Environment», Vol. 5, n.º 4, p. 199-208.

MITROIU, Mircea-Dan (2013) − *Linepithema humile (Mayr 1868)*. «Fauna Europea, Version 2.6.2». [accessed 1 September 2015] at <URL http://www.faunaeur.org/distribution_table.php>.

NEPOMUCENO, Rui (2006) – *A Conquista da Autonomia da Madeira. Os conflitos dos séculos XIX e XX*. Lisboa: Caminho.

NEWELL, Wilmon; BARBER, Thomas Caldwell (1913) – *The Argentine ant*. «US Department of Agriculture, Bureau of Entomology Bulletin», n.º 122.

NEWITT, Malyn (2005) – *A History of Portuguese Overseas Expansion, 1400-1668*. London: Routledge.

NOVAK, V. (1947) – *Exotictí mravenci ve sklenících Prazské bota-nické zahrady*. «Casopis Ceské Spolecnosti Entomologické», Vol. 4, p. 144-146.

PAOLERA, Gerardo della; TAYLOR, Alan M., *ed.* (2003) – *A New Economic History of Argentina*. Cambridge: Cambridge University Press.

PAOLI, Guido (1922a) – *Isolator, per difendere le piante contro la formiga dell' Argentina*. «Redia», Vol. XV.

____ (1922b) – *Un modo di difendere le piante contro gli assalti della formica d'Argentina*. «La Costa Azzurra Agrícola – Floreale», Vol. II, n.º 6.

____ (1923a) – *La formica dell'Argentina: descrizione, costumi, mezzi di lotta: istruzioni e decreti*. «La Costa Azzurra Agrícola – Floreale», Vol. II, n. suppl. *al* n.º 5.

____ (1923b) – *The Argentine Ant*. Citta di Sanremo.

PAULY, Philip J. (2002) – *Fighting the Hessian Fly: American and British Responses to Insect Invasion; 1776- -1789*. «Environmental History», Vol. 7, n.º 3, p. 485-507.

PAX, F. (1915) – *Beobachtungen über das Auftreten der "argentini-schen Ameisen", Iridomyrmex humilis MAYR, in Schlesien*. «Schlesische Monatsschrift des Obst-, Gemüse- und Garten-baus, Breslau», Vol. 4, n.º 3, p. 33.

PERFETTO DI TRENTO (1926) – *Circolare Lotta contro la Formica Argentina*. «Bollettino Ufficiale Prefettura di Trento», Vol. dicembre 1926, n.º 51425.

PINTO-GANHÃO, J. F. (1958) – *A luta contra a Formiga Argentina*. «Agros», Vol. 41, n.º 5, p. 1-7.

PISARSKI, Bohdan (1957) – *On the occurrence of exotic species of ants in Poland*. «Fragmenta Faunistica», Vol. VII, n.º 11, p. 284-288.

POOLEY, Simon (2013) − *Historians are from Venus, Ecologists are from Mars*. «Conservation Biology», Vol. 27, n.º 6, p. 1481-1483.

RADCHENKO, A. (2004) − *Formicidae*. «Fauna Europaea version 1.1». [accessed 1 September 2015] at <URL http://www.faunaeur.org>.

REES, E. A. (1995) – *Stalinism and Soviet Rail Transport, 1928-41*. London: Palgrave Macmillan UK.

REPARTIÇÃO DE SERVIÇOS FITOPATOLÓGICOS (1950) – *A Formiga Argentina. Novo método de combate.* Lisboa: Serviço Editorial da Repartição de Estudos, Informação e Propaganda, Ministério da Economia.

ROURA-PASCUAL, Núria; SUAREZ, Andrew V.; GÓMEZ, Crisanto; PONS, Pere; TOUYAMA, Yoshifumi; WILD, Alexander L.; PETERSON, A. Townsend (2004) – *Geographical potential of Argentine ants (Linepithema humile Mayr) in the face of global climate change*. «Proceedings of the Royal Society of London. Series B: Biological Sciences», Vol. 271, n.º 1557, p. 2527-2535.

ROUSSEAU, Pierre (1961) − *Histoire des transports*. Paris: Fayard.

SARMENTO, Alberto Artur (1937) – *Subsídio para o estudo das formigas da Madeira*. Funchal.

SCALERA, Riccardo; GENOVESI, Piero; ESSL, Franz; RABITSCH, Wolfgang (2012) – *The impacts of invasive alien species in Europe*. Copenhagen: Publications Office.

SCHMITZ, Ernest (1896) – *As formigas da Madeira*. «Annaes de Sciencias Naturaes», Vol. X, p. 55-58.

____ (1897) – *As formigas da Madeira (add)*. «Annaes de Sciencias Naturaes», Vol. XI, p. 77.

SCHWARTZ, Robert; GREGORY, Ian; THÉVENIN, Thomas (2011) – *Spatial history: railways, uneven development, and population change in France and Great Britain, 1850-1914*. «Journal of Interdisciplinary History», Vol. 42, n.º 1, p. 53-88.

SENATO DELLA REPUBLICA ITALIANA (1948) – *Disegno di Legge: (Discussione e approvazione) Autorizzazione della spesa di lire 200 milioni peri il finanziamento della lotta contro la formica argentina e della spesa di lire 1.000.000 per assicurare il normale funzionamento dei servizi fitopatologici*.

SERI, L. (1923) – *Instruzioni sulla lotta contra la Formica argentina e risultati ottenutti a Roma negli anni 1921-22-23*. «Bollettino della Reale Stazione di Patologia Vegetale».

SERVIÇOS ENTOMOLÓGICOS E PATOLÓGICOS (1929) – *Notas discriminativas dos Serviços de tratamento de árvores, plantas e culturas. Estação Agrária da Madeira*. Arquivo Regional da Madeira, Junta Geral do Distrito do Funchal, EAM [544-2].

SILVA, Fernando Augusto da; MENESES, Carlos Azevedo de (1921) – *Elucidário madeirense: obra destinada a comemorar o quinto centenario do descobrimento da Madeira*.

SILVEIRA, Luís Espinha da; ALVES, Daniel; LIMA, Nuno Miguel; ALCÂNTARA, Ana; PUIG, Josep (2011) – *Population and railways in Portugal, 1801-1930*. «Journal of Interdisciplinary History», Vol. 42, n.º 1, p. 29-52.

SILVESTRINI, R. (1922) – *La Formica Argentina*. «R. Laboratorio di Entomologia Agraria Portici», Vol. 1, p. 1-7.

STITZ, H. (1916) – *Formiciden*. «Ergebnisse der Zweiten Deutschen Zentral-Afrika Expedition», Vol. 1, p. 369-405.

____ (1939) – *Hautflügler oder Hymenoptera. 1 Ameisen oder Formicidae*. «Die Tierwelt Deutschlands und der angrenzenden Meeresteile, nach ihren Merkmalen und nach ihrer Lebens-weise», Vol. 37, p. 1-428.

SUAREZ, Andrew V.; HOLWAY, David A.; CASE, Ted J. (2001) – *Patterns of spread in biological invasions dominated by long-distance jump dispersal: insights from Argentine ants*. «Proceedings of the National Academy of Sciences», Vol. 98, n.º 3, p. 1095-1100.

Taunton Courier, and Western Advertiser, 1922.

Taxon Details. «Fauna Europaea» [accessed 24 August 2015] at <URL http://www.faunaeur.org/full_results.php?id=81173>.

TITUS, Edward Sharpe Gaige (1905) – *Report on the "New Orleans" ant (Iridomyrmex humilis Mayr)*. «US Bur Entomol Bull», Vol. 52, p. 79-84.

TUCCI COLACE, Antonio; ESPADALER, Xavier (2013) – *Invasive species: the Argentine ant (Linepithema humile) distribution and supercolony presence on Majorca island*.

TSUTSUI, Neil D.; SUAREZ, Andrew V.; HOLWAY, David A.; CASE, Ted J. (2001) – *Relationships among native and introduced populations of the Argentine ant (Linepithema humile) and the source of introduced populations*. «Molecular Ecology», Vol. 10, n.º 9, p. 2151-2161.

VOGEL, Valérie; PEDERSEN, Jes S.; GIRAUD, Tatiana; KRIEGER, Michael J. B.; KELLER, Laurent (2010) – *The worldwide expansion of the Argentine ant: Global expansion of the Argentine ant*. «Diversity and Distributions», Vol. 16, n.º 1, p. 170-186.

Walsall Advertiser, 1911.

Western Morning News, 1922.

WETTERER, James K.; ESPADALER, Xavier; WETTERER, Andrea L.; AGUIN-POMBO, Dora; FRANQUINHO AGUIAR, António (2006) – *Long-term impact of exotic ants on the native ants of Madeira*. «Ecological Entomology», Vol. 31, n.º 4, p. 358-368.

____ (2007) – *Ants (Hymenoptera: Formicidae) of the Madeiran Archipelago*. «Sociobiology», Vol. 49, n.º 3, p. 265-297.

WETTERER, James K.; WILD, Alexander L.; SUAREZ, Andrew V.; ROURA-PASCUAL, Núria; ESPADALER, Xavier (2009) – *Worldwide spread of the Argentine ant, Linepithema humile (Hymenoptera: Formicidae)*. «Myrmecological News» Vol. 12, p. 187-194.

WOODWORTH, C. W. (1908) – *The Argentine ant in California*. «Cal. Agr. Exp. St.», Vol. 38, p. 11.