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Sustainability: Science, Practice and Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tsus20

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To cite this article: Cecilia Smith-Ramírez, Adriana Rendón-Funes, Mario Leiva, Marina Arbetman, Marcelo Aizen & Luis Agüero (2023) Non-compliance with the World Trade Organization agreements by exporters of the European bumblebee, *Bombus terrestris*, Sustainability: Science, Practice and Policy, 19:1, 2256173, DOI: 10.1080/15487733.2023.2256173

To link to this article: https://doi.org/10.1080/15487733.2023.2256173

SUSTAINABILITY: SCIENCE, PRACTICE AND POLICY
2023, VOL. 19, NO. 1, 2256173
https://doi.org/10.1080/15487733.2023.2256173

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RESEARCH ARTICLE

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Non-compliance with the World Trade Organization agreements by exporters of the European bumblebee, *Bombus terrestris*

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ABSTRACT

International companies commercially rear bumblebees worldwide, the trade of which is regulated through agreements established by the World Trade Organization (WTO). Scientific studies have shown multiple negative effects of introduced commercial bumblebees on native bees in Japan, Australia, Sweden, Israel, Chile, and Argentina, calling into question the compliance of exporting with some of the established WTO international sanitary regulations. We analyzed international WTO sanitary regulations focusing on the international trade of bumblebees from the European Union (EU) and Israel, especially regarding bumblebee exports to Chile and their side effects in neighboring Argentina. We have gathered evidence showing that exporters of bumblebees do not comply with WTO international trade agreements in at least two ways: (1) the quality of commercialized bumblebees differs from the quality declared in their certifications, and (2) the countries that sell the bumblebees violate sanitary agreements, producing negative effects on other native pollinating insects and causing a cascade of adverse impacts affecting both the environment and agriculture. This situation suggests that companies that raise bumblebees are currently in breach of WTO regulations and continue to contribute to major environmental damage in southern South America and elsewhere.

ARTICLE HISTORY
Received 26 December 2022
Accepted 27 August 2023

KEYWORDS
Commerce regulations; globalization; pathogens; sanitary and phytosanitary measures

Introduction

Intensification in the cultivated area of pollinator-dependent crops is globally increasing (Aizen et al. 2008; Magrach et al. 2023). Unfortunately, instead of changing agricultural practices toward sustainable food production, supplementation with domesticated pollinators (e.g., the western honey bee, *Apis mellifera*) has usually been the chosen answer to resolve pollination needs (Goulson, Lye, and Darvill 2008). Because of its sociality, high capacity for temperature thermoregulation, adaptation to confined conditions, and ability to release pollen from anthers requiring vibration, in recent decades much effort has been put into managing and domesticating bumblebees (Velthuis and Van Doorn 2006). *Bombus* (i.e., the bumblebees), a genus that includes about 260 species worldwide, represents a group of large social bees that are efficient pollinators of thousands of plant species under a wide range of climatic conditions, including low temperatures (Williams 1998). In fact, industrial rearing of managed bumblebees for the pollination of greenhouse- and open-field crops, such as tomato, eggplant, and blueberry, among many others (Velthuis and Van Doorn 2006; Aizen et al. 2020), has become a highly profitable industry that has boosted bee trade and promoted bee invasions (Morales et al. 2013; Aizen et al. 2019).

Bumblebee rearing is a massive and worldwide trade geared toward crop pollination, with three transnational companies, Koppert (from the Netherlands, with subsidiaries in Slovakia), Biobest (from Belgium, with subsidiaries in Slovenia), and BioBee (from Israel) dominating the market (see Supplementary Material 1A). The bumblebee species most commonly reared and traded by these companies is the European *Bombus terrestris*, which

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/15487733.2023.2256173.

generates yearly profits of nearly US$140 million for Koppert and US$70 million for BioBest (Dun and Bradstreet 2022). After its introduction, it has escaped to the wild in at least nine countries and territories across two continents (CABI 2019) (Figure 1). According to information provided by the Chilean Agricultural and Livestock Service (SAG), Biobest, Koppert, BioBee, and other smaller companies, sold to Chile about 1,505,526 inseminated colonies and queens from 1997 to 2021 (Figure 2). Although the importation of *B. terrestris* was rejected by Argentina, it was first detected in that country on the eastern side of the Andes, about 900 kilometers (km) south of where it was introduced for the first time in Chile just ten years earlier (Figure 2; Torreta, Medan, and Abramovich 2006). By 2017, the South American range of European *B. terrestris* extended over 5,000 km, from near the border with Bolivia to the southernmost tip of the continent in Tierra del Fuego (Montalva et al. 2017). This species is also invasive in Japan, Tasmania, and New Zealand (Aizen et al. 2020), and its use as a domesticated bee probably increased its dominance in countries like Ireland, Sweden, and Israel, within its native range (Bommarco et al. 2012; Dafni 1998).

The international trade of bumblebees is regulated by the World Trade Organization (WTO 2021a), which sets the status of international law. In the organization's own words:

> The World Trade Organization (WTO) is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business.

Within such agreements, in 1995, the WTO established the Agreement on Sanitary and Phytosanitary Measures, to create regulations to "protect human, animal or plant life or health" and "to improve the human health, animal health and phytosanitary situation in all Members." Belgium and the Netherlands (main producers and importers of bumblebees) as well as Spain (a rising bumblebee exporter), have been WTO members since January 1, 1995 (when it was created), and were previously members from January 1, 1948 of the General Agreement on Tariffs and Trade (GATT) which preceded the WTO and was absorbed by this organization. Israel, a major bumblebee exporter outside the European Union,[1] has also been a member of the WTO since April 21, 1995 while Chile has been a member of the WTO since 1948 and is the only known importer of *B.*

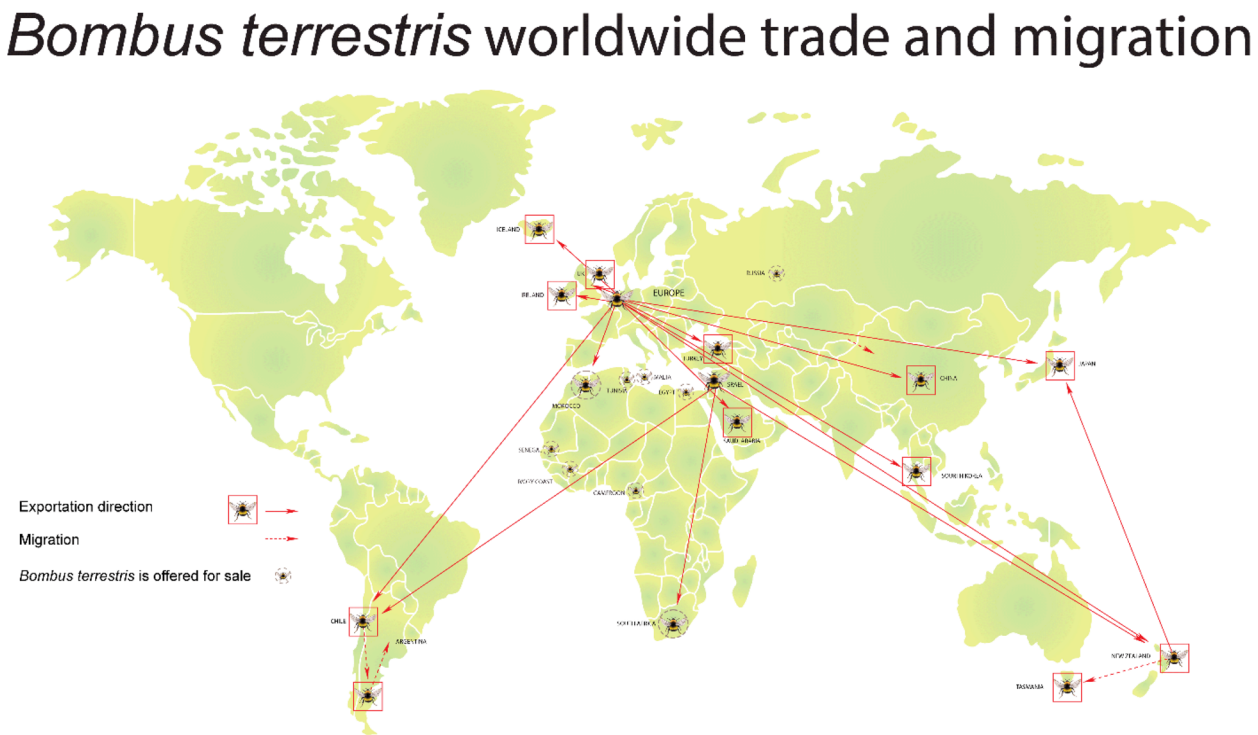

Figure 1. Global trade map of *Bombus terrestris* exportation (shown with squares) from the Netherlands, Belgium (Koppert and BioBest companies, respectively), and Israel (Biobee company).
Note: Dotted circles indicate locations where *B. terrestris* is listed for sale, but there is no confirmation of actual importation. Uruguay and Mexico are not included, since importations were occasional and they are no longer importing. This information is limited by the availability of data for certain areas. For example, we do not include trade within the inner mainland of Europe or the occasional exportations from Spain to Chile. Exportation to Japan is restricted but not prohibited. The information presented here was obtained on official websites, social media (links derived from https://www.koppert.com; https://www.biobee.com) and scientific references (Lee and Kim 2019; Montalva, Arroyo, and Ruz 2008; Kratochwil 2016; Dafni et al. 2010). This map was modified and updated from Montalva, Arroyo, and Ruz (2008).

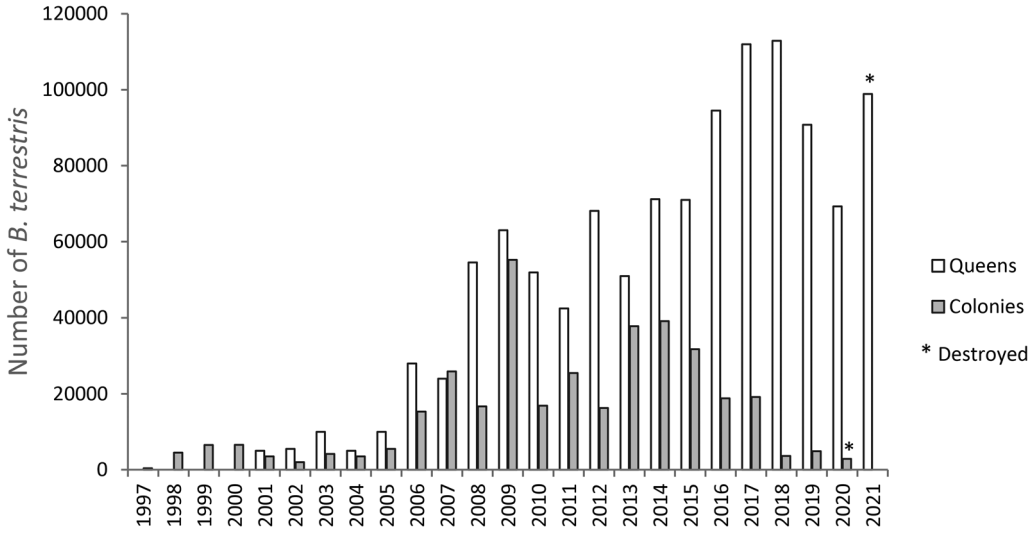

Figure 2. Number of *Bombus terrestris* imported to Chile annually since 1997.
Note: Data derived from Aizen et al. (2019) (1997–2009) and letters from SAG (the Chilean Agricultural and Livestock Service, 2009–2021) in both cases invoked through transparency law. The original letters from SAG in Spanish can be found at DOI:10.6084/m9.figshare.19539349. The asterisks (*) means that some colonies were destroyed by SAG because *Apicystis bombi* was detected in a batch from Slovakia (Koppert company) in 2020 and in a batch from Belgium (Biobest company) in 2021.

terrestris in the Americas (WTO 2021b). In this article, we analyze the compliance of the EU and Israel with international WTO sanitary regulations regarding the bumblebee trade with Chile and its consequences in Argentina.

There is evidence that commercialized *B. terrestris* and the pollen supplemented for the journey (estimated timeframe from one to two weeks, or more if quarantine time is required) to the final destination, supplied by Koppert, Biobest, and Syngenta (EU companies), and then sold to the UK carried highly virulent pathogens within the bees' intestine (i.e., *Vairimorpha bombi* (previously known as *Nosema bombi*), *Crithidia bombi*, and *Apicystis bombi*) (Graystock, Goulson, and Hughes 2014). Moreover, Trillo, Brown, and Vilà (2019) found high prevalence of *Vairimorpha* sp.[2] (58.3% to 83.3%) in colonies of *B. terrestris* bought from Koppert by Spanish farmers in 2015. The lack of adequate sanitary care in the trade of commercial bumblebees produced in Europe has also had several negative impacts for the native bee fauna in South Korea and Japan (Lee and Kim 2019; Goka et al. 2001, Goka, Okabe, and Yoneda 2006). Owing to such published evidence, the bumblebee trade has been recognized as one of the current global threats to biodiversity. The United States, Mexico, Norway, and the Canary Islands have banned the importation of bumblebees due to their invasiveness and the risk of pathogen transmission to native bees (Graystock et al. 2013; Evans et al. 2023; Figueroa et al. 2023; Winter et al. 2006). In Argentina, importing *B. terrestris* is not officially banned but has been rejected by the government and the police have destroyed the few colonies that have arrived. In Japan, imported bumblebees are prohibited in open crop areas but are allowed in greenhouses, with restrictions (Goka 2022).

In recent years, at least one of the main companies (BioBest) has been employing gamma radiation to reduce the prevalence of pathogens in the pollen that is used in factories for breeding *B. terrestris* (Annette von Oyster, personal communication; Hidalgo et al. 2020). However, despite these precautions, *A. bombi* was found by SAG (Chile) in 2020 in a shipment that originated from Biobest and in 2021 in a shipment that originated from Koppert (Supplementary Material 1B, 1C). In fact, the trade of *B. terrestris* has been harmful due to its pathogens and invasiveness in most countries to which it has been introduced (see above) with several negative environmental impacts (Figure 3, Supplementary Material 2). There are several pathogens carried by *B. terrestris* that are shared with *A. mellifera* (Maharramov et al. 2013) as well as evidence of transmission of pathogens brought by *B. terrestris* to South America infecting the native giant Patagonian bumblebee, *B. dahlbomii* (Arbetman et al. 2013; Schmid-Hempel et al. 2014) and it is suspected of affecting the Highland bumblebee (*B. funebris)* by decreasing its population number due to pathogen spillover (MMA 2015; Figure 4).

These reasons have led to recognition that the bumblebee trade has a global problem and is one of the worst current threats to biodiversity (Sutherland et al. 2016; Aizen et al. 2019). This bumblebee trade is at odds with international agreements resolved at

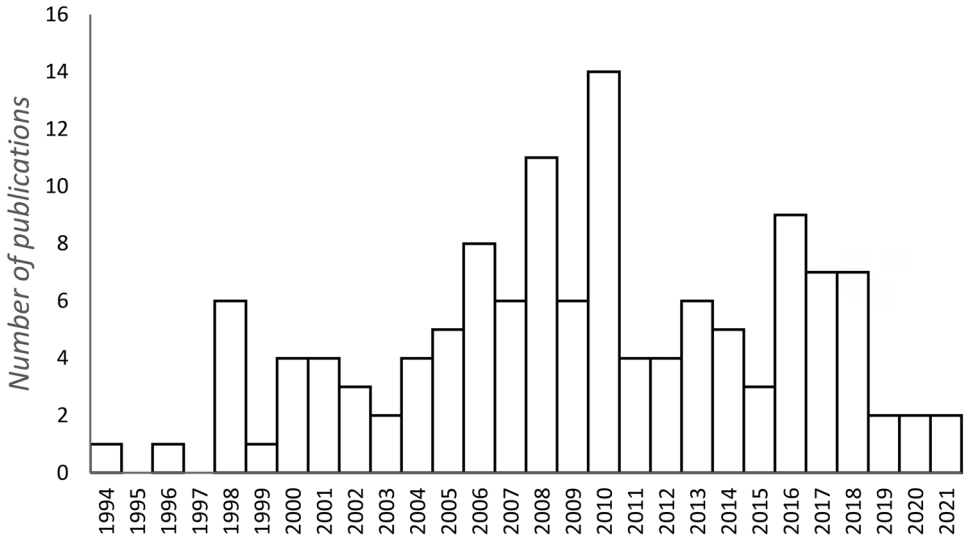

Figure 3. Annual number of publications reporting negative impacts of *B. terrestris* on biodiversity between 1994 and mid-2021.
Note: The complete list of publications included in this figure can be found in Supplementary Material 2.

Figure 4. Pictures of threatened Chilean bumblebees.
(A) *Bombus dahlbomi* in blueberry flowers. Photo by Benito Cortés-Rivas. (B) *Bombus funebris*. Photo by Rodrigo Barahona-Segovia. (C) *Bombus terrestris* (Linnaeus 1758) robbing nectar from a Faba bean flower and decreasing its reproductive fitness (Smith-Ramírez et al. 2021).

the Sixth Conference of the Parties to the Convention on Biodiversity (COP6) to control the spread of invasive species (CBD 2022) which were signed by, among others, the EU on behalf of all member states.

Despite these threats, the transaction of invasive species such as *B. terrestris* is continuing, leading us to examine violations to WTO agreements. The ultimate goal of this article is to determine responsibilities to mitigate the negative effects that this trade has generated in the past and continues to produce in the present with respect to the biodiversity and economies of importing and neighboring countries. We also aim to encourage a rethinking of the consequences of marketing negligent trading in consideration of contemporary European law governing biological resources.

Methods

To conduct this analysis, we used a mixed-methods approach that involved reviewing available documentation on the WTO website, communicating with SAG through Chile's Transparency Law, analyzing the responses received, and reviewing the literature to assess the negative impacts of *B. terrestris* on plants or other bees and bumblebees.

First, we reviewed official WTO documents, including current signatories of the agreements, the original GATT (1947) together with amendments (1994), the agreements from the Tokyo Round (1973–1979) and the Uruguay Round (1986–1993) of negotiations, the agreements on sanitary and phytosanitary standards (SPS), and later agreements or decisions officially made by the WTO. We used this information to gain a comprehensive understanding of the trade regulations related to the importation of *B. terrestris*.

Second, we communicated with SAG from 2019 to 2022 using Chile's Transparency Law to request information regarding the number of *B. terrestris* (queens and colonies) imported monthly and annually since their first importation in 1997, the name and country of origin of the exporting centers, and information about pathogens detected in importations. We received responses from SAG, which are included in Supplementary Material 1 (excerpted translations in English).[3] This information allowed us to examine the importation practices of *B. terrestris* into Chile and to assess the effectiveness of the sanitary regulations in place.

Finally, we performed a systematic review of the scientific literature from 1994 to 2021 regarding the negative impacts of *B. terrestris* on plants or other bees and bumblebees. We included field and lab studies in this analysis, warnings about the spread of this invasive species, and studies of pathogen spillover. Studies with neutral or positive effects on plant reproduction (three studies) or studies in greenhouses were not considered. For this review, we used the Web of Science and Scopus databases as they provide access to peer-reviewed studies.[4] This search produced 155 sources in the Web of Science and 153 in Scopus. Repeated articles were subtracted to create a single list, and unrelated articles to our objective were discarded. We also reviewed the reference list of 50 key articles, and any literature cited that was not previously listed was included, resulting in a total of 127 publications about the negative impacts of *B. terrestris* on biodiversity.

Analysis of the WTO agreements for EU and Israel

When a transaction involving living organisms takes place between signatory countries of the WTO, both agree on its characteristics. The endorsement of this particular agreement is, in essence, an act of good faith. In the case of the bumblebee trade, these criteria seem to have been violated in two ways: (1) in terms of quality, which affects the real value of the good; and (2) in terms of sanitary measures, by trading a species that carries detrimental pathogens and with an established highly invasive behavior affecting native plant species native Hymenoptera (insects) as well as sustainability and crop production.

Infractions in the stipulated value and quality of imports

Article 1 (Supplementary Material 3A) regulates the value and quality of imported goods, taking into account those restrictions that "are imposed or required by law or by the public authorities in the country of importation," and that "do not substantially affect the value of the goods." The exporters seem to have met neither the specific requirements nor the quality conditions. Since its first importation in 1997, Chile required that bumblebees should be free of the following pathogens:[5] *Melittobia acasta, Sphaerularia bombi, Locustacarus buchneri*, and *Apicystis bombi* (Supplementary Material 1D). Each bumblebee shipment is required to have a certificate indicating the absence of these pathogens. However, evidence shows that at least *A. bombi* was introduced along with the traded bumblebees (Plischuk and Lange 2009; Arbetman et al. 2013; Figure 2; Supplementary Material 1B), as detailed in the next subsection and in violation of specific agreements stipulated as part of WTO rules.

The WTO states that the party receiving imports can review the quality and other aspects of the

goods (Supplementary Material 3B). In Chile, this revision consisted only of an external inspection, because from 1997 to 2019, SAG's own institutional capabilities did not include a molecular analyses lab or the vision to do the analysis abroad. During the first 18 years of importation, SAG detected external parasites in *B. terrestris* (Supplementary material 1E) and in 1998, the agency also reported detection of *V. bombi* (an internal pathogen). As previously stated, *A. bombi* was also detected in 2020 and 2021 when SAG implemented molecular lab analysis.

WTO regulations also stipulate that when the quality of the goods is not as stated in the original agreement, the importing party may request explanations. If the answer is not satisfactory and the two parties cannot reach an agreement, the importing country has the right to appeal for the stipulated value (Article 11, Supplementary Material 3A). There are several reasons why this clause was not used or ignored in the bumblebee case including that the importing countries did not notice that the certificate contained incorrect information, were negligent about the protection of biodiversity, or deemed it cumbersome or inconvenient to activate WTO's conflict-resolution process. For instance, the UK, a country with high environmental standards, imported *B. terrestris* from Syngenta, BioBest, and Koppert, and yet, no legal actions were taken when it was discovered that the certificates issued by these companies were not completely truthful (Graystock et al. 2013; Smith-Ramírez et al. 2018).

There is another agreement (see Supplementary Material 3C) that protects developing countries such as Chile at the time of the first importations, from importations that might be harmful to the food supply. Pollinators provide an important environmental service for food production with economic value for local farmers (see Hipólito et al. 2019; Gallai et al. 2009), and although the importation of *B. terrestris* could be beneficial for greenhouse-crop production (Velthuis and Van Doorn 2006), it can also have negative impacts. On one hand, it can be detrimental for the yield of other crops like raspberry because of flower damage due to overvisitation or broad beans by nectar robbery (Aizen et al. 2014; Sáez et al. 2017; Smith-Ramírez et al. 2021; Figure 4). On the other hand, displacement and population reduction caused by pathogen spillover and competition with other bees can reduce pollination efficiency (Aizen et al. 2020) and, in the case of commercial *A. mellifera*, the population reduction can negatively affect the beekeepers' industry (Chalcoff et al. 2022).

The ongoing expansion of *B. terrestris* in Chile (Montalva et al. 2017) and neighboring Argentina (Aizen et al. 2019), and projected expansion in Brazil (Acosta et al. 2016) and China (Naeem et al. 2018), have been anticipated in studies published since 1994 (Figure 3). The value of the imported goods should be reassessed by involved parties (EU, Israel, Chile) due to noncompliance with agreements both in terms of damage to other pollinators and claims of being free of pathogens and owing to potential negative economic side-effects on the yield of non-target crops (Aizen et al. 2020).

Agreement on sanitary and phytosanitary measures (SPS)

Violation of the rules associated with SPS agreements by the companies of EU member countries (and Israel) has occurred in two separate ways as detailed below.

Commercialization of bumblebees harboring pathogens

Studies by Arbetman et al. (2013) and Plischuk and Lange (2009) have demonstrated that before the arrival of *B. terrestris,* the bumblebee species living in Patagonia were free of *A. bombi*. More than 400 museum specimens of other native *Bombus* species (i.e., *B. atratus, B. morio, B. bellicosus, B. opifex, B. tucumanus*), sampled outside of Patagonia between 2005 and 2009, were also free of this pathogen.

Maharramov et al. (2013) investigated the genetic origin of the pathogen *A. bombii* found in bees after the introduction of *B. terrestris* and concluded that the detected genetic haplotypes were compatible with the European strain of this widespread parasite.[6] In addition, other independent studies found that the introduction of *B. terrestris* had a striking negative impact on the population of the native bumblebee, *B. dahlbomii* (Schmid-Hempel et al. 2014; Morales et al. 2013), suggesting that the mechanism involved could be related to pathogen transmission. There is also evidence of abrupt decline in the abundance of the native bumblebee, *B. dahlbomii*, as well as wild populations of *A. mellifera,* following the arrival *B. terrestris* (Smith-Ramírez et al. 2014; Montalva et al. 2017).

Commercialization of highly invasive species

Invasive species are a threat worldwide; *B. terrestris* has been shown to be one of the most extensively documented biological invasions in recent times (Arbetman et al. 2013; Morales et al. 2013; Schmid-Hempel et al. 2014; Smith-Ramírez et al. 2014; Pérez 2018; Montalva et al. 2017; Aizen et al. 2019). Scientific evidence regarding the invasive

capacity of *B. terrestris* (along with their capacity for carrying and transmitting pathogens) had been published and thus was available before Chile began to commercially import this bumblebee (Figure 2; Smith-Ramírez et al. 2014; Durrer and Schmid-Hempel 1994; Schmid-Hempel 1995; Dafni and Shmida 1996). Invasiveness due to high abundance of this species has already caused both ecological and economic (non-quantified) problems in South America. For example, *B. terrestris* has damaged the production of raspberry and fava bean crops, as well as harmed native pollinator populations as stated above (Aizen et al. 2019; Smith-Ramírez et al. 2021; Supplementary Material 2).

Discussion

We found enough published and official information to provide evidence that exporters of bumblebees failed to declare the true health status of the exported bees in their certificates. This mistake has been damaging the health of wild bees in importing countries for decades, harboring potential risks to crops and native plants and causing harm to other pollinators native to both nearby countries and countries farther away. These failures contradict the essence and spirit of the WTO/SPS agreements.

The knowledge published regarding the risks to the environmental health of pollinators predates the importation of *B. terrestris* to Chile and several other countries. Moreover, in 2018, Biobest recognized publicly to a Belgian newspaper the damage caused by *B. terrestris* in South American ecosystems (Smith-Ramírez et al. 2018). A few days after this interview, BioBest stated on its website that the damage was already done and, thus, there was no reason to stop the exportation of *B. terrestris* to Chile (Smith-Ramírez et al. 2018). This means that the company has recognized its own negligence, but instead of implementing any precautionary measures (Moore and Gross 2012) based on the environmental damages incurred and the WTO regulations, it has decided to continue the trade. As such, it cannot be argued that this trade was initiated in good faith, based on past and contemporary evidence that suggests it was not within treaty guidelines.

For these reasons, the responsibility for these consequences of biodiversity damage in South America is shared between all exporters (and even the importing countries), and we contend that both Chile and Argentina should bring this dispute to the WTO, as their rights under the agreements are being infringed upon. In particular, based on scientific data Article 2, Paragraph 2;[7] Article 5, Paragraphs 1 to 4;[8] and Article 6, Paragraph 1[9] of the WTO SPS Agreement were violated, causing sanitary, ecological, and economic problems.

Neither the exporting nor importing member countries established effective sanitary measures and precautionary actions to manage the risks posed by the introduction and spread of industrially-reared alien bumblebees. Members of EU countries and Chile have both failed to take effective interventions even after mounting evidence of fraudulence and negligence. Furthermore, Chilean authorities not only transgressed their mandate on animal healthcare in Chile, but also failed—and continue to fail—to comply with phytozoosanitary agreements with neighboring countries such as Argentina.

Finally, there has been a slow reaction by the relevant institution that oversees this commercialization in Chile, namely SAG. This slow action has resulted in the creation of a risk analysis 20 years after the start of the commercial bumblebee trade (SAG 2018). This study concludes that there is a high threat of pathogen spillover from *B. terrestris* to the native *B. dahlbomii* (SAG 2018), an expectation corroborated by other existing scientific investigation (Arbetman et al. 2013; Schmid-Hempel et al. 2014). The risk analysis conducted by SAG in 2018 was the basis for the completion of a very delayed process of "harmonization" in the trade relationship, in consideration of Chilean domestic regulations. The harmonization measures are detailed in Resolution 5889 which was published in 2019 and went into effect in 2020 (SAG 2019); however, we contend that these harmonization measures are clearly insufficient. Harmonization means the implementation of common national sanitary and phytosanitary measures that are in line with international standards, guidelines, and recommendations, as indicated in Article 3 of the WTO/SPS Agreement.[10] Unfortunately, some countries with deficient controls by health systems regarding international trade—such as most, if not all, developing countries—have neither the infrastructure nor the technical capacity to affect the tougher screening measures detailed in that agreement. Such is the case of Chile, which lacked the infrastructure to detect internal parasites until 2019 when this information started to be registered in *B. terrestris*' importations (Supplementary Material 1B and 1C). While Chile was classified as a developing country when the bumblebee trade started in 1997, it was subsequently recategorized as a developed country in 2010. However, so far there has been no assistance provided by the exporting companies or hosting countries for Chile to implement sanitary measures to protect its native species, counter to the recommendation in the SPS agreements.

According to the 1981 SAG resolutions (Supplementary Material 1D and 1E) about *N. bombi*, bumblebee sellers violated the rules stated in Paragraph 3, Article 6, and Article 7 of the WTO/SPS Agreement[11] because they certified that the installations and their exported bumblebees were free of pathogens. The lack of adequate sanitary care in the trade of commercial bumblebees from Europe has also been demonstrated in South Korea, where imported colonies of *B. terrestris* carried *Melittobia acasta*, a small parasite that affects bee larvae[12] (Lee and Kim 2019), and in Japan, where imported colonies of commercial bumblebees imported from Europe carried *Lacustacarus buchneri*, a mite that infects the bees' tracheal systems, from Europe to Japan (Goka et al. 2001; Goka, Okabe, and Yoneda 2006). Therefore, the export of infected bumblebees seems to be a common practice, in clear violation of the established agreements of international trade; thus, the real quality and value of the product exported are not as declared.

Despite the existence of some regulations around commercial bee-colony health (*A. mellifera* and *Bombus* spp.) for European exporter-members (see 92/65/EEC in European Commission 1992), this measure does not cover all pathogens (Trillo, Brown, and Vilà 2019). A similar gap it is also noted in the sanitary code of the Office International des Epizooties (OIE), known also as the World Organization for Animal Health) where *B. terrestris* it is only mentioned and associated because of the possibility of *Aethina tumida*[13] infestation (Chapter 9.4 of Terrestrial Animal Health Code, OIE 2012). In the case of Chile there is no clear explanation as to why SAG, which has access to abundant literature regarding bumblebee diseases, only required screening for the pathogens listed above and left unconsidered other extremely common pathogens found in *B. terrestris* and other members of the *Bombus* genus such as *Crithidia bombi, V. bombi*, and *V. ceranae*.

In practical terms, Chile should ban importation of this bumblebee species by invoking Article XIX from GATT,[14] and could even use the legal framework of a national security emergency if necessary (Article XXI from GATT[15]), while launching studies and restoration programs aimed at the amelioration of native pollinators and the services they provide to ecosystems and crops. Such a legal framework has been used before by Russia in 2014 to justify measures that blocked trade with Ukraine (WTO 2014) and by the United States to impose trade barriers on steel and aluminum imports from the EU, Canada, and Mexico in June 2018 (Pelc 2018) and to increase tariffs on Chinese products in September 2019 (Armstrong 2019).

Conclusion

We found that exporters of *B. terrestris* from the EU and Israel have failed to declare in their certificates the true health status of their merchandise, and/or have also exported an invasive species, thus failing to comply with WTO agreements. This mistake has been damaging the health of wild bees and bumblebees and harboring potential risks to crops, native plants, and other pollinators in the importing countries and their neighboring regions. These failures contradict the essence and spirit of the WTO/SPS agreements.

Given that the importation of alien-invasive bumblebees continues, safeguards in trade should be applied immediately between WTO member countries to prevent the entrance of even more infectious agents carried by *B. terrestris* individuals. Also, the actors that are legally accountable for the major environmental damage caused by this bee trade should be identified and economic penalties imposed upon the responsible parties to pay for the best possible courses of action to remediate damages in both Chile and Argentina. Also, restoration programs in affected countries should be implemented (as has occurred in Japan) after the importation of *B. terrestris* was restricted. In the words of the WTO "if it [the responsible country, in our case the EU and Israel] continues to break an agreement, it should offer compensation or face a suitable response that has some bite—although this is not actually a punishment: it's a 'remedy', the ultimate goal being for the country to comply with the ruling" (WTO 2023). We suggest the following restoration program: (1) Provide a fund to finance long-term research and long-term management to recover native bee species affected in southern South America; (2) Finance management to recover possible *A. mellifera* populations affected by *B. terrestris*, (3) Fund the promotion of the use of native pollinators as nature-based solutions (NbS) in South American farming, (4) Stop the importation of *B. terrestris* to southern South America, and (5) Finance the control of feral *B. terrestris*, at least in southern South America.

Notes

1. Despite not being a member of the EU, Israel receives support from the bloc to align its legislation with EU standards, including areas such as SPS and food safety (Delegation to Israel 2021).
2. *Vairimorpha*, a genus of *parasitic microsporidia*, affects winter diapauses of bumblebee queens, disrupting their hibernation process (Orlova et al. 2023). The parasite negatively impacts bees, particularly bumblebees, by interfering with digestion

and nutrient absorption in the gut. This can result in shortened lifespans, reduced reproductive success, and decreased colony size and productivity. Larvae are more vulnerable to infection, and the disease can spread within colonies through infected adults, perpetuating the infection at the colony level (Orlova et al. 2023). In the case of *V. bombi* infection, adult bumblebees experience a shortened lifespan. Moreover, infected colonies suffer from reduced size, resulting in fewer worker bees, drones, and queens, which adversely affects the colony's strength and productivity (Yanagisawa et al. 2023).

3. The original responses in Spanish can be found at DOI: 10.6084/m9.figshare.19539349 and DOI: 10.6084/m9.figshare.19543783.
4. We performed a search of Scopus and Google scholar database during June 2021 for all studies published, using the following search term combinations: ((“*Bombus terrestris*” OR “*B. terrestris*”)) AND ((damag* OR invas* OR robb*)).
5. Adverse effects by pathogens (SAG 2018): a) The adverse effects of *M. acasta* on bees include smaller size of adult bumblebees, potential colony death, limitation of new queen production, and economic impacts on crop pollination. Additionally, it could have a significant environmental impact on biodiversity, especially affecting endangered bee species such as *B. dahlbomi*. b) *A. bombi* causes significant mortalities in bumblebees, due to the reduction of stored fat. This can affect their ability to survive the winter and establish new colonies, potentially leading to a decline in bumblebee populations. While its impact on honey bees is less clear, *A. bombi* is considered a potential threat to non-resistant bees, and further research is needed to understand its full adverse effects on bees. c) *S. bombi* adversely affects bumblebees by infecting and sterilizing hibernating queens. It impedes the development of the bumblebee's ovaries and alters their post-hibernation behavior. Parasitized queens are unable to establish new colonies, reproduce, and ultimately die after disseminating juvenile nematodes into the soil, potentially affecting bumblebee populations. Additionally, there have been observations of *S. bombi* in queens of the *Vespula* genus, suggesting a possible impact on other Hymenoptera species as well.
6. A haplotype is a group of specific DNA variants or alleles that are closely located along a single chromosome and tend to be inherited together as a unit. These genetic variations remain linked and are passed down through generations without frequent recombination between them.
7. Article 2, Paragraph 2 requires members (countries) to apply sanitary or phytosanitary measures based on scientific evidence and they should not be maintained without sufficient scientific evidence to support them. An exemption (Article 5, Paragraph 7) allows provisional adoption of measures when scientific evidence is insufficient, but review and additional information gathering are mandatory.
8. Article 5, Paragraphs 1 to 4 require that members must base their sanitary and phytosanitary measures on risk assessments, considering scientific evidence, production methods, and economic factors. They should aim to minimize negative trade effects.
9. Article 6, Paragraph 1 requires members to adapt their sanitary and phytosanitary measures to the characteristics of the region from which the product originates and to which it is destined. Factors like diseases or pest prevalence, the existence of eradication or control programs, and appropriate criteria or international guidelines should be considered in this adaptation process.
10. Article 3 aims to promote international harmonization of sanitary and phytosanitary measures to facilitate trade while ensuring the protection of human, animal, and plant life or health. It encourages the use of international standards, transparency in implementing measures, and support for developing countries in meeting the requirements.
11. Article 6, Paragraph 3 requires exporting members claiming pest- or disease-free areas to provide evidence to the importing member and allow access for inspection and testing to verify the claim. Article 7 emphasizes transparency and requires prompt publication of changes in sanitary and phytosanitary measures. Members must make their adopted regulations public and establish enquiry points to address queries from other members. When a proposed regulation could impact trade and deviates from international standards, members must notify and consider comments from other members.
12. When a bee larva is infected by *M. acasta*, the parasite lays its eggs on or inside the larva's body. As the *M. acasta* eggs hatch, the young parasitic insects start feeding on the bee larva, which can harm or even kill the larva. This can lead to problems for the bee colony, as the infected larvae may not grow properly, and the overall population of bees can be affected.
13. According to SAG (2018) risk assessment, *A. tumida* has various adverse effects on bees, particularly honey bees. It can cause the dispersion of hives, leading bees to abandon their nests. The feeding behavior of *A. tumida* larvae causes significant damage to honeycomb structures, potentially resulting in the complete collapse of the nest. The beetle's introduction would have a significant economic impact on the export of bees and honey, as additional measures would be required to ensure freedom from *A. tumida*. Moreover, there could be socio-environmental impacts, particularly affecting small-scale beekeepers and agricultural employment. Overall, the negative impact of *A. tumida* on bees is considered to be very high.
14. Article XIX from GATT allows countries to take emergency action on imports of specific products if a surge in imports threatens domestic producers of similar products or directly competitive products. It permits the suspension or modification of tariff concessions temporarily to prevent or remedy the injury. Prior notice and consultation with other parties are required, but in critical circumstances, provisional action can be taken before consultation.
15. Article XXI from GATT provides security exceptions that enable countries to take actions deemed

necessary for safeguarding their essential security interests. While these exceptions typically cover areas like fissionable materials, arms trade, and actions in line with the United Nations Charter for international peace and security, they also encompass other emergencies in international relations. These exceptions acknowledge that countries may need to enact measures for their security without being restricted by the agreement.

Acknowledgements

We express our gratitude to Ben Woodcock, Nadia Sánchez, Liliana Galdámez, Devon Barone, Emma Gleeman, and the anonymous reviewers for their many contributions and valuable insights while reviewing the manuscript. We also thank Benito Cortés-Rivas, Rodrigo Barahona-Segovia, and Claudio Almarza for the pictures in Figure 4.

Data availability

All data are available in the main text or the Supplementary materials. Supplementary materials are deposited in Figshare. For details, including the relevant DOIs, please refer to the Supplementary Materials.

Disclosure statement

The authors disclose that they have no competing interests to declare.

Funding

This study was funded by SURPASS2, Newton Fund Latin-American Program (NERC)NE/S011870/2, and Institute of Ecology and Biodiversity (IEB), AFB170008; Grant ANID/BASAL FB210006.

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