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When introduced equals invasive: normative use of "invasive" with ascidians

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Abstract

This study aimed to understand the use of "invasive species" as a normative concept and discuss its implications in conservation science, using introduced ascidians worldwide as model species. A specific search in Web of Science was performed and articles suitable for analysis were selected. Each article was classified according to the type of environment, species under study, type of effects and spread that ascidians are linked to. Most of the 184 articles analysed did not consider dispersal or effects as study subject (82 and 71%, respectively). Most research was conducted in laboratory conditions (41%) or human-made environments (32%) or indicating few escapes to natural environments. Almost half of the articles (47%) were made with the six more conspicuous introduced ascidians and this raised to 70% while considering articles that worked with two or more (pooled) species. The normative use of "invasive" is widely used regarding introduced ascidians. Spread and effects, necessary conditions to consider a species as invasive, are notoriously understudied. Most research was not conducted in natural environments and over a few species, weakening the perception of introduced ascidians as a conservation problem. To discuss the extent of the normative use of invasion science is important to distinguish two phenomena: are some species intrinsically problematic for conservation (i.e. invasive) or is the movement of non-native species (i.e. biological invasion) the conservation problem? By using invasive as a normative concept, we risk ending with a weakened concept potentially hindering the progress of invasion science.

Keywords Ascidians · Normative use · Invasive · Effects · Dispersion · Human-made environments

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Introduction

There is continuous debate over the threat that invasive species present to natural environments (Davis et al. 2011; Simberloff et al. 2011). Among other ideas, two main and opposite points of view are notorious: there are scientists warning of the perils that invasive species are (e.g. Richardson and Ricciardi 2013; Russell and Blackburn 2017), and scientists highlighting that many issues related to invasive species are sometimes biased or misrepresented (Thompson 2014; Chew 2015). The debate has recently reached a new peak since those who call for a "less biased view" of invasive species are considered deniers (Ricciardi and Ryan 2017). Central to this debate is the lack of agreement on what an invasive species is (Davis and Thompson 2000; Richardson et al. 2000; Valéry et al. 2008; Blackburn et al. 2011), and the concomitant confuse and biased use of the term invasive within academia (Pereyra 2016; Warren et al. 2017).

Davis (2009) differentiated two types of uses for invasive species, normative and descriptive. The former refers to the nominal usage, whereas the latter refers to a description of the ecological behaviour of a species. An example of the normative use includes how ecologists commonly refer to "invasive species" while the actual "invasive entity" are some populations of a given species (Colautti and MacIsaac 2004; Kueffer et al. 2013). This use of the term is analogous to a Realistic vs Constructivist point of view (see Larson 2011), where the realistic represents some characteristics that the species have (i.e. a species *is* invasive), and the constructivist represent some interpretation we made of the ecological behaviour of the species (i.e. a species *is considered* or not invasive). A similar example of the normative use of invasive is when having evidence of invasive behaviour on some members of a given taxon; such behaviour is generalised to all the members of such taxon (e.g. Hulme et al. 2013; Maggi et al. 2015). Although Davis (2009) has stated that the normative use of invasive species is quite frequent and the results presented by Pereyra (2016) indirectly suggest the same pattern, there is a lack of information of which usage is more common in invasion science.

Here we have taken this concept and tested it using introduced ascidians. As a group, introduced ascidians have been the focus of growing interest in recent years (Lambert 2007; Fig. 1) and are considered model species to study biological invasions (Zhan et al. 2015). There are several features of introduced ascidians that make them a useful model to test for the normative usage of the term invasive. First, they have limited natural dispersal (or spread) capabilities and, accordingly to most current definitions, the successful spread is a necessary condition that makes a species invasive (Blackburn et al. 2011). Second, some introduced ascidians can cause important ecological or economic effects, and in many cases that makes them more likely to be studied (Pyšek et al. 2008; Barney et al. 2013), or increases the likelihood that they would be considered invasive (e.g. Zhan et al. 2015). Considering this, we conducted a literature search to determine how introduced ascidians escape from its introductions points (i.e. spread) and how often they produce effects (i.e. impacts) on natural communities or human activities. Also, given the sessile nature of most ascidians, they are frequently studied using artificial samplers and/or in human-made environments rather than natural environments (Marraffini et al. 2017; Tait et al. 2018), allowing us to keep a record of the kind of environment where the studies have been performed in (i.e. natural vs. artificial environments). We also registered which species of ascidians the articles were focused on, and what types of study were performed with each species. This approach allowed us to identify research gaps, understudied topics and/or less prominent species (cf. Zhan et al. 2015). In this article, we followed the framework

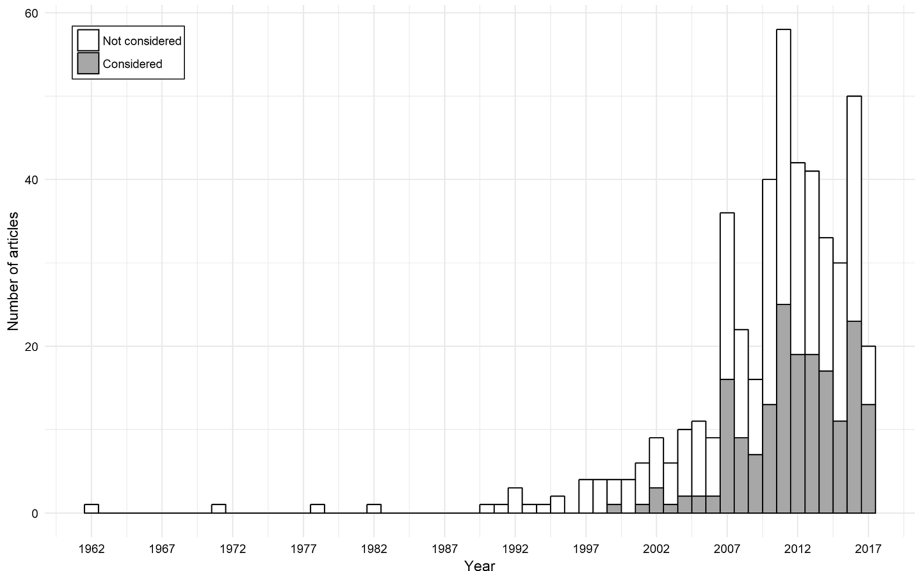

Fig. 1 Number of articles found in Web of Science from January 1960 to July 2017. The grey bars represent the number of articles considered in this study

proposed by Blackburn et al. (2011) to classify invasive species, considering that an invasive species (or population) is that which have surpassed both dispersal and environmental barriers and is successfully spreading, reproducing and surviving in natural environments. We also used "effect" instead of "impact" since the definitions are mostly analogous (Chew and Carroll 2011).

Methods

An articles search using Web of Science on July of 2017 with the terms "ascidians" or "tunicates" plus "introduced", "invader", "invasive", non-native", "non-native", "non-indigenous", "alien" and "exotic" was conducted. The full-text of each article was examined to determine the suitability of papers for inclusion in the posterior analysis. Articles that labelled their species of study as "invasive" or "invader" in any part of the article were considered for subsequent analysis. If both authors did not agree with the inclusion of an article, it was not considered.

As proposed by Blackburn et al. (2011), dispersal across the landscape is a necessary condition to consider a species as invasive. For each article in our analysis, we categorised the type of dispersal and identified in which cases spread was a natural process or facilitated by human-related activities. Alongside this, the site where the studies were performed was also recorded and categorised (Table 1), considering that a species that spread beyond its introduction point should be studied in natural environments. The articles were also categorised accordingly to the effects studied (ecological or economic; Table 1) if any, considering that are important drivers to study invasive species. This allowed us to identify if the normative use of invasive are being used (i.e. by calling invasive to introduced ascidians without proof of escape or environmental effects).

Table 1 Criteria used for the classification of the articles used in the analyses

Clasified by	Type	Criteria
Considered for analysis	Considered	The species is unequivocally identified as invasive or invader by the author/s
	Not considered	The species is not identified as invasive or invader, even when some keywords can be found across the text
Species	One species	Study with 1 species of ascidians
	Several species	Study with 2 or more species
Category	Autoecology	The study explores life history traits of the population/species
	Experimental	The study is a field and/or laboratory experiment
	Community studies	The study explores community related characteristics (i.e., species assemblages) on natural and/or human-made environments.
	Review	Reviews in a broad sense, mostly theoretical studies.
	Genetic studies	Genetic studies involving biogeographical, methodological o taxonomic approaches
	Model	Conceptual and/or mathematical models dealing with dispersal or effects of ascidians
	Report	Articles describing new records of distribution, experiences to control-eradicate ascidians or technical papers
Environment	Human-made	The study was performed in human-made environments or structures: ports, docks, aquaculture structures and facilities, etc.
	Natural	The study was performed in natural environments (natural seafloor, bays, estuaries), even when man-made structures are present
	Laboratory	The study was performed mostly in laboratory conditions (tests, experiments, molecular analyses), regardless to the site where the samples were taken
	Human-made and Natural	The study was performed partially in natural and partially in human-made environments.
	Human-made and Laboratory	The study was performed partially in laboratory and partially in human-made environments.
	Others	Articles in silico (editorials, reviews)
Dispersion	Natural	The study described the spread of the species by its own capabilities
	Human-assisted	The study described the spread of the species by human related activities
	Human-assisted and Natural	The study described both types of spread
	Not considered	The spread was not described or evaluated

Table 1 (continued)

Clasified by	Type	Criteria
Effects	Ecological	The study evaluated the ecological effects of the species
	Economic	The study evaluated the economic effects of the species
	Ecological and Economic	The study evaluated both types of effects
	Not considered	The effects were not described or evaluated

The articles were also classified into eight broad science-type categories (Table 1) to describe the different approaches used when invasive ascidians are studied. Finally, the articles were categorised by the species under study, highlighting those conducted with the six most conspicuous globally introduced ascidians: *Didemnum vexillum*, *Styela clava*, *Botryllus schloressi*, *Botrylloides violaceus*, *Ciona intestinalis* complex and *Microcosmus squamiger* (Zhan et al. 2015). Many ascidians are morphologically complex, sometimes involving several cryptic species (e.g. Zhan et al. 2010, 2015). Species belonging to a complex (e.g. *Ciona intestinalis*) were considered as such, even when the original authors do not refer to them as a complex. When authors were unable to identify the individuals under study to species level, we included the identification as they originally reported in the publication, with no further changes (e.g. *Didendum* sp.). When other taxa were included, we only categorized the ascidians involved. This allows us to determine if there is a concentration of studies over a particular group of species or if it is more evenly distributed across many ascidians considered invasive. All information was recorded on a spreadsheet while data manipulation and figures were done using the language R (R Core Team 2017), combined with many tools of the package Tidiverse over RStudio (Wickham 2017; RStudio 2017).

Results

The search in Web of Science yielded 472 articles, of which 184 articles met the criteria used to include them in the analyses (Fig. 1; Table S1). Considering the type of environment, almost 21% of the studies (38 of 184 articles) were made in natural environments (including the natural environment in combination with some type of human-made environments; Table 1; Fig. 2). Most of the studies were conducted in laboratory (41%; 75 articles) or human-made environments such as docks, marinas and aquaculture sites (32%; 59 articles), while only one study was made in both laboratory and human-made environment combined. Similarly, almost 29% (53 articles) of articles studied the effects (both ecological and/or economic) of introduced ascidians, while the remaining 71% (132 articles) did not consider them. The effects classified as ecological were more prevalent (21%, 39 articles) than those considered economic (6%, 11 articles), while only two articles considered both types of effects together. The type of dispersal of the species was not considered in most cases (82%, 151 articles) (Fig. 2). When studied, human-assisted dispersal was more prevalent than natural (21 and 9 of 33 articles, respectively), while three articles described both types of dispersal (Fig. 2). Concerning the types of studies, the more prevalent categories were *Genetic studies* and *Experimental* studies, both with 25% of the articles (46 of 184 articles, Fig. 2), followed by *Autoecology* (16%, 31 articles) and *Community studies* (13%, 24 articles).

Of those articles that assessed ecological effects, 22 of 42 articles were made in natural environments (Fig. 3). Interestingly, half of those articles were made with artificial samplers (i.e. PVC plates, Petri dishes). Regarding economic effects, 13 articles were found. Most of half of them (7 of 13 articles) were ecotoxicological studies, testing different kinds of compounds to deal with invasive ascidians fouling commercial aquaculture structures (e.g. Rolheiser et al. 2012; McCann et al. 2013; Comeau et al. 2015), or with antifouling paints (e.g. Filip et al. 2016). Only a few of them (3 of 13 articles) addressed the effects of invasive ascidians on the commercial aquaculture structures (Comeau et al. 2015, 2017;

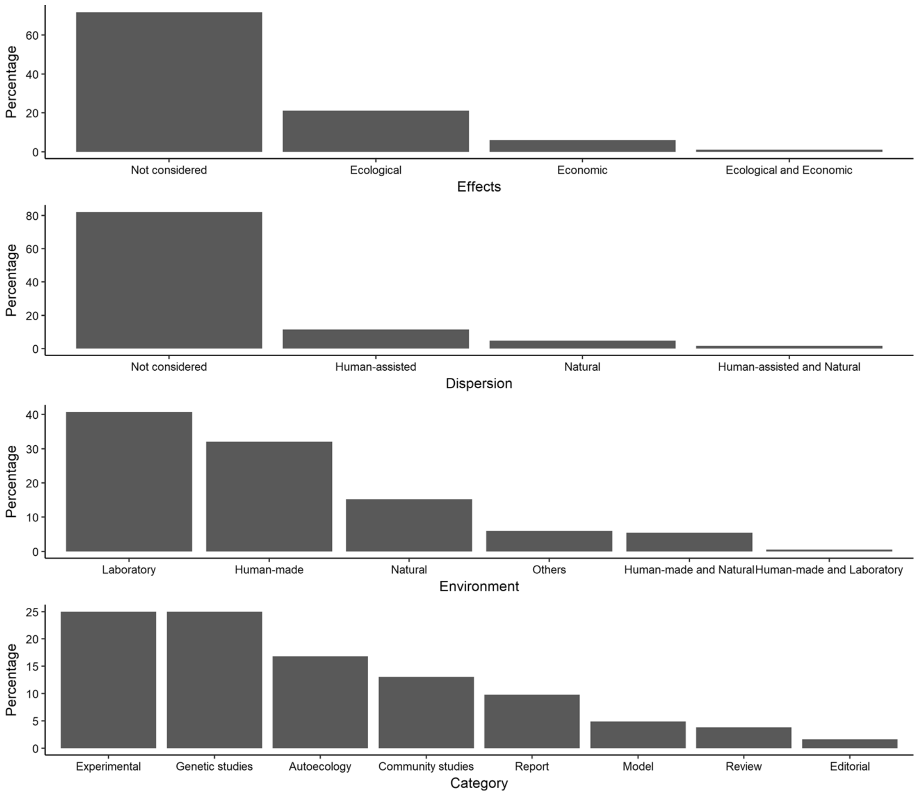

Fig. 2 Distribution of the articles across the categories considered to classify them. Please note that the axis scales differ between categories

Fletcher et al. 2013), and only one dealt with life story traits of an invasive ascidian (Kanamori et al. 2017). All but two of them were made in non-natural environments.

Regarding the spread of invasive ascidians, most of the articles (82%, 151 articles) did not take into account this aspect of the invasion. Human-assisted dispersal was the category with more articles (11%, 21 articles), followed by natural dispersal (5%, 10 articles), while both types of dispersal combined were considered in three articles. The single most important study category that considered dispersal type was *Genetic study*, with 11 cases (nine considering human dispersal, two considering both dispersal types combined).

Many of the articles considering human-assisted dispersal relied on modern genetic tools to determine how invasive species were introduced or to evaluate if the events of introduction were one or more (e.g. Lacoursière-Roussel et al. 2012; Maltagliati et al. 2016), or to link multiples occurrences of a species with a particular type of vector (e.g. Goldstien et al. 2011). All but one (Çinar 2016) worked in non-natural environments. With respect to natural dispersal of the introduced ascidians, there were some articles evaluating different types of dispersal (e.g. Fletcher et al. 2013; Stefaniak and Whitlatch 2014) or dealing with the level of dispersal that introduced ascidians have outside the port of introduction (e.g. York et al. 2008; McCann et al. 2013; Simkanin et al. 2012; Collin et al. 2013).

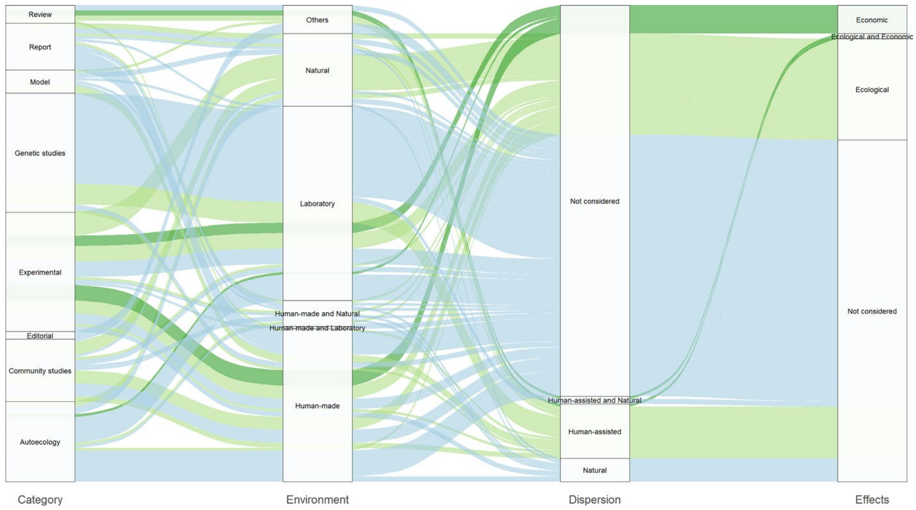

Fig. 3 Alluvial diagram (Brunson 2017) showing the relationships among the articles grouped according to different types within Category, Environment, Dispersion and Effects. The blocks represent the proportion of types for each variable, and stream fields between the blocks represent the relative contribution of the articles corresponding to each type through all variables. The stream fields are colour-coded according to the interaction of Dispersion and Effects and is easier to interpret them from right to left

When the articles were grouped across all the categories together, interesting patterns emerged (Fig. 3). *Genetic studies* were performed mostly in laboratory conditions and did not consider dispersal. Many studies labelled as *Experimental* considered the effects of introduced ascidians, but most of those experiments were performed in human-made environments (Fig. 3). Similarly, articles studying ecological effects were those classified as *Autoecology* and *Community studies* and were also performed mostly in human-made environments (Fig. 3). Articles considering natural dispersal were mostly related to *Autoecology* or *Experimental* articles. The remaining categories showed lower representation, as follow: 10% Reports (due mostly to first records in species distribution, 18 articles), 4% Model (nine articles), < 4% Review (seven articles) and 1.6% Editorial (three articles, Table S1).

When analysing the articles by the species of study, almost half of the articles (near 47%, 86 of 184 articles) were made with the six most conspicuous introduced species (*cf.* Zhan et al. 2015). Other than those, many studies considered species pooling (here as "Several species", 29%, 54 articles, Table 1), of which 43 articles also consider at least one of same six most conspicuous species (Fig. 3). Conjunctly, those species comprised almost 70% of the studies made with introduced ascidians. *Styela plicata* was the only species not remarked by Zhan et al. (2015) which had more studies than one of the six model species (Fig. 4). *Pyura praeputialis*, a well known introduced species in Chile (e.g. (Castilla et al. 2004a) was studied the same number of time as *Microcosmus squamiguer*, while eight species were the focus of only one article (Fig. 4).

Considering only the subset of studies that included at least one of the six most studied ascidian species Zhan et al. (2015), we observed a variety of approaches (Fig. 5). The simple most studied species was *D. vexillum* with 31 articles, followed by *C. intestinalis* complex and *S. clava* with 18 and 15 articles, respectively. The other three species have received less attention with 11 (*B. schlosseri*), 7 (*B. violaceus*) and 5 (*M. squamiger*)

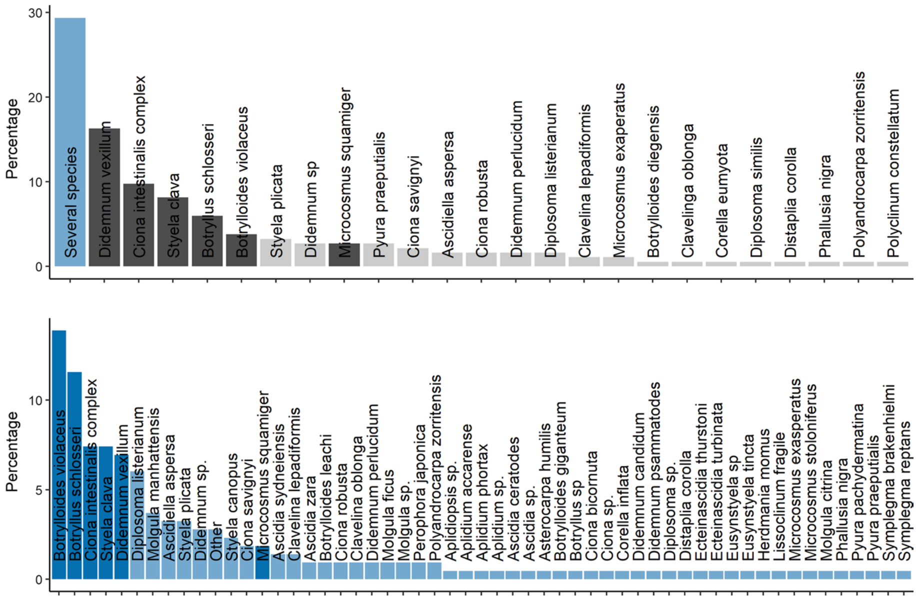

Fig. 4 Percentage the articles that studied each species. Upper panel: Articles studying a single species as main subject, where “Several species” correspond to the articles considering 2 or more species; lower panel: detail of the species considered within the group “Several species”. Highlighted in a darker colour are the six species described by Zhan et al. (2015) as model invasive ascidians

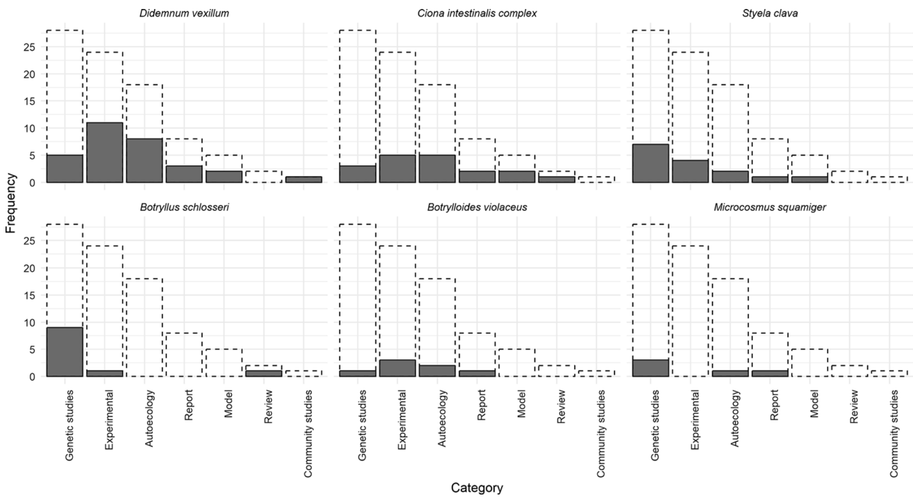

Fig. 5 Detail of the studies made with the six model ascidians described by Zhan et al. (2015). Dashed bars: total of articles of each type considering those six species. Solid bars: articles of each type per species

articles, respectively. Articles working with *D. vexillum* and *C. intestinalis* complex were mostly *Experimental* and *Autoecology* studies, followed by *Genetic studies* (Fig. 5). Articles working with *S. clava* and *B. schloesseri* focused mostly on genetic and experimental studies (Fig. 5). *Models*, *Reviews* and *Community studies* received less attention with most of those species.

Discussion

This is the first work that comprehensively reviews and summarises the studies made with introduced ascidians (but see Aldred and Clare 2014; Zhan et al. 2015). The results presented here strongly denote the normative use of the concept of invasive while working with introduced ascidians. This normative use is uncovered by the fact that most of the research has been performed in human-made environments or laboratory conditions and a little proportion of the articles worked on the spread aspects of the invasion (a necessary condition to be invasive). Also, little research has been done considering the effects of introduced ascidians that needs to be quantified for a species to be considered invasive. In addition, we have found that most of the research was focused to those species considered more relevant or troublesome. Jointly, both results signals to the normative use of invasive, which is not unexpected in invasion science since invasive species are routinely portrayed as a great threat to the environment (Chew 2015). In this sense, this study is intended to highlight several implications that the normative use has for the study of introduced ascidians, mainly related to the association between invasive species and conservation.

Aspects of an invasion

Dispersal is a fundamental aspect for considering whether a species is invasive (Blackburn et al. 2011). Nevertheless, very few articles worked on this aspect of the invasion by ascidians. Determining if this pattern is driven by the economic or logistic constraints on studying ascidians in the wild, the inherent difficulty of studying spread in the marine realm (Sherman et al. 2016), or reflects a lack of interest about this topic, is beyond the objectives of this work. It is possible that research was conducted mostly in human-made environments due to researchers applying the invasive concept to modified environments (e.g. anthromes; Ellis & Ramankutty 2008). This does not seem to be the case, however, because the articles reviewed often referred to introduced ascidians by "disrupting native communities" (e.g. Cima et al. 2015), and almost no references to modified environments have been found. Certainly, introduced ascidians can be spreading and we may be underestimating it (e.g. Bullard et al. 2007; McCann et al. 2013). However, even in the case that a species appears in two locations, is difficult to identify a priori if the species spread freely or was translocated by human actions; or even if the events of introduction were more than one and/or are interrelated. Moreover, given that they usually are found in human-made environments and the poor dispersal capabilities shown by introduced ascidians (Simkanin et al. 2012, 2016; Collin et al. 2013; Zabin et al. 2018) it is reasonable to assume that in most cases those species were not spreading by themselves. Similarly, there is a lack of studies intended to assess the effects of introduced ascidians, but they are consistenly portrayed as having negative effects. Regarding ecological effects (41 articles), most of the evaluations were carried out with artificial samplers (23 articles, e.g. Marraffini et al. 2017) and six in laboratory conditions. Many of those studies (data not shown, but see Castilla et al. 2004a, b; Manríquez et al. 2016) provide non-conclusive evidence of the capacity of introduced ascidians to displace others species. In this regard, the study performed by Blum et al. (2007) is routinely cited to support those negative effects (it has been cited

118 times as of writing this article), providing evidence of species richness depletion with the presence of *Ciona robusta* (referred as *C. intestinalis*). However, in a replica of this study, non-significant effects on species composition were found, highlighting the context-dependence of the effects caused by introduced species (Robinson et al. 2017). Similarly to what occurred with *spread*, we have found little evidence to support the notion of introduced species having (negative) ecological effects in natural environments. In particular, those studies that did not use artificial samplers have usually found non-conclusive or even contrasting results (e.g. Simpson et al. 2016; Long and Grosholz 2015; Wong and Vercaemer 2012; Smith et al. 2014; Gittenberger 2007; Castilla et al. 2004a, b).

Considering effects and dispersion together, it is clear that most articles do not inquire on these aspects of invasion by introduced ascidians (Fig. 3). Considering that a great proportion of the articles reviewed were not made in natural environments, a generalisation about the effects of invasive ascidians should be done more carefully (Lawton 1999; Guerin et al. 2018). None of the articles considering effects, both ecological and economic, also considered the spread of the ascidians (Fig. 3). Similarly, just a few articles that considered spread, both natural and human-assisted, inquire about the effects of those ascidians, while the majority of the articles did not consider any type of effects (Fig. 3). Of those articles considering spread, they focused on a variety of approaches, while *Genetic studies* where the most important category when studying the spread of introduced ascidians (Fig. 3).

Normative use

The normative use of the invasive has several inconveniences. Some authors have argued for the use of a neutral language in invasion science as a form to avoid further confusion (Colautti and MacIsaac 2004; Pereyra 2016). Others recommend just the opposite since this is the way how it is occurring in practice (Heger et al. 2013) and how science advance (Hodges 2008). While these differing perspectives are being discussed, agreements among researchers working in invasion science have been hard to achieve. In light of the articles reviewed, it seems that invasive ascidians are part of a larger group of "invasive species", which are commonly referred to as a major environmental and conservation problem (Chew 2015; Ricciardi and Ryan 2017). We want to point out that this may not be the case with introduced ascidians. Invasive ascidians are portrayed as having "strong competitive abilities" (Rosa et al. 2013), but we have found little to none evidence of this. Similarly, ascidians are supposed to be able to spread rapidly and successfully colonize a variety of dramatically different environments (e.g. Huang et al. 2016; Lins et al. 2018), but once again we found little evidence of this and moreover, the evidence signals the contrary (Simkanin et al. 2012, 2016; Zabin et al. 2018). The normative use of invasive with ascidians allows us to consider them as an environmental problem because (allegedly) all invasive species are. To date and to the best of our knowledge, there is no extinction reported in the marine realm caused by an introduced species (Bellard et al. 2016). Introduced ascidians do not appear to promote extinctions in natural environments, and the evidence of competitive displacement of native species is scarce and contradictory (Blum et al. 2007; Robinson et al. 2017), and contain several limitations that invasion science needs to consider before over-emphasize it as a recurrent phenomenon (cf. Maier 2012). Theoretically, introduced do not equate to invasive, and invasive do not equate to problematic species (Blackburn et al. 2011). In practice, in the case of introduced ascidians at least, introduced equates to invasive (and invasive resemble problematic) even when there is little evidence of (negative) ecological effects. How common is the normative use in the broad invasive science literature? We can only guess, but there is some evidence that strongly suggests that this is the case (e.g. Heger et al. 2013; Pereyra 2016).

Species under scrutiny

As occur with other taxa (*cf.* Hulme et al. 2013; Maggi et al. 2015), most of the studies made with invasive ascidians were made with a small group of species (Fig. 3). The six species indicated by Zhan et al. (2015) as model invasive species were present, alone or within pools of species, in 76% of the studies reviewed here (87 and 42 articles respectively). The remaining 24% of the studies were made exclusively with other 58 species of introduced ascidians (Fig. 4). These results leads us to a scenario where there is plenty of studies about a fraction of the introduced ascidians (with little knowledge about those characteristics that allow to consider them as invasive), with a noticeable lack on information about most introduced ascidians (Figs. 2, 5). It appears that those introduced ascidians which are already considered invasive (i.e. normative use) are therefore studied in detail for diverse reasons but not for those characteristics that make them invasive. The characteristics that make a species invasive are rarely addressed (cf. Pereyra 2016) and seems that the normative use of invasive it routinely used as an endorsement of the importance of some studies.

Zhan et al. (2015) have proposed those six species as model species for studying invasions in the marine realm. However, we suggest to expand this approach to improve the knowledge of invasions by ascidians as a whole, with more research focused on understudied species, understudied topics (mainly, *effects* and *spread*), and conducted more often in natural environments (e.g. Pereyra et al. 2017). If we want to answer the pressing topic related to the risk that non-native introductions represent (Ricciardi and Ryan 2017) we need to concentrate more effort in how "human-made" assemblages differ from "natural" assemblages, or how introduced ascidians differ from native ascidians (e.g. Poe and Latella 2018). By concentrating most of the research effort in few species, we will have much information (not without gaps) about a subgroup of species, but this approach does not seem appropriate to characterise the broad category of introduced ascidians. Based on the evidence reviewed, it seems that ascidians are being introduced outside their native range and transported to subsequent human-made habitats, but there is little information about "natural spreading" to the surrounding environments. In this context, the question arises: why this movement of species represent a problem? Understanding the normative use of the term invasive is important to conceptualise two different phenomena: are some species intrinsically problematic for conservation (i.e. invasive) or the movement of non-native species (i.e. biological invasion) is a conservation problem? (cf. Lins et al. 2018). We understand that whatever reason behind considering invasive ascidians as a problem (i.e. rapid colonisation, displacement of other species) should not be invoked in this scenario. We encourage our colleagues to inquire deeply in this aspect of invasion science so we can determine as a group if we are talking about invasive or simply introduced ascidians, and if the later turn out to be the case, why they should (and if they should) be considered a conservation problem (cf. Shackelford et al. 2013).

Final considerations

We have shown that the normative use of "invasive" regarding introduced ascidians is common practice. Following current theory (Blackburn et al. 2011; Larson 2011) we cannot consider many of them as invasive but instead introduced (or naturalized). We realise that across a "process of invasion" (Blackburn et al. 2011) we may be missing some interesting stages that are worth considering. Species on other stages of the invasion process are valuable research topics (e.g. naturalised, Richardson and Pyšek 2012) but they should not be lightly considered invasive. On the other hand, in some cases species may already occupy natural environments beyond their native range, where the study of the spreading process may not be as necessary as other topics. We also want to remark that we are not denying that some introduced ascidians can produce negative economic or ecological effects in parts of their introduced ranges, affecting local economies or hidden biodiversity for instance. However, the normative use of invasive with species that may not be invasive is far from being a semantic argument because labelling species with little supporting data may translate to research into sandboxed (biased) knowledge as well as unnecessary real-world actions for conservation policies (Davis et al. 2011). We also want to emphasises that introduced ascidians can have positive effects, both economic and ecological, as is the case of *P. praeputialis* in Chile (Castilla et al. 2004a, b, 2014; Manríquez et al. 2016). While our work did not investigate further on those aspects, positive effects of introduced species are far less studied than negative effects (Thompson 2014), and to have a complete picture of the risk that introduced ascidians represent, both aspects need to be addressed. To assume that an introduced ascidian would colonise natural environments and displace native species because they are invasive, while there is a lack of evidence or even the evidence shows the contrary, is to perpetuate the normative use of the term invasive, which was already recognised in theory but diminished in practice (Davis 2009). By using invasive as a normative concept, we risk ending with a weakened concept potentially hindering the progress of invasion science.

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