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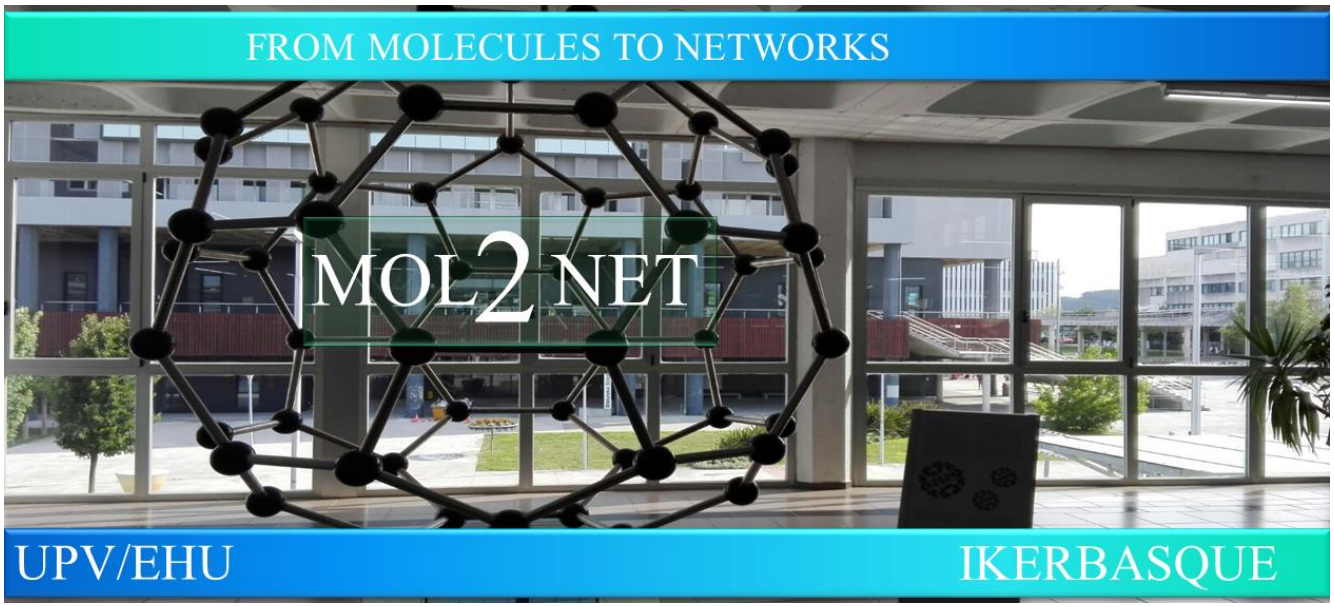

Analyses of distribution, population dynamics, threats, and conservation strategies applied to endemic marine angiosperms from the Tropical Atlantic Ocean

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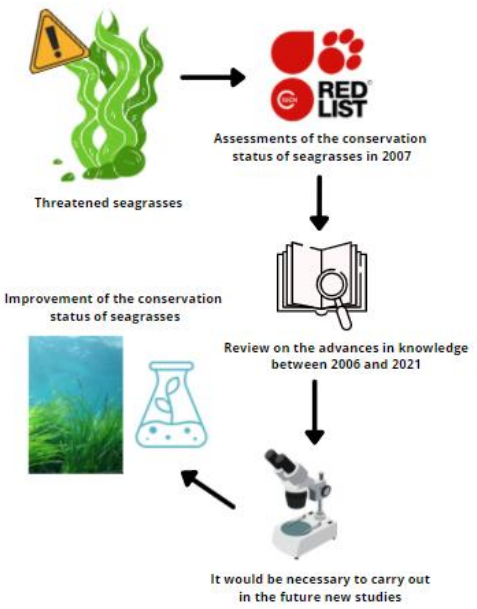
Graphical Abstract	**Abstract**
	Marine angiosperms form highly productive, complex and ecologically important ecosystems, so their conservation is essential. Unfortunately, various threats have been documented that are reducing the conservation status of natural populations. To know the current state of conservation of endemic marine angiosperms in the Tropical Atlantic Ocean, a bibliographic review has been carried out on the advances in knowledge made between 2006 and 2021 about their distribution, population dynamics, threats and *in situ* and *ex situ* conservation strategies. The most studied species in this time is *Thalassia testudinum*



Banks & Sol. Ex K.D. Koenig and, in addition, it is the one that has the greatest number of *in situ* conservation strategies implemented. However, in general, the results on distribution, population dynamics and threats are limited for the rest of the species considered in this work. Regarding *ex situ* conservation, it is scarce for all the species studied and only two of them (*T. testudinum* and *Syringodium filiforme Kütz*) have material preserved in germplasm banks. *Halophila baillonis* Asch. Ex Dickie is the species to which the least conservation strategies have been applied, probably due to the fragmentation of its populations. Finally, in order to improve the conservation status of the seagrasses studied in the present work, it would be necessary to carry out in the future new studies on the taxonomy, distribution, seed physiology and *in vitro* culture.

Keywords: *Seagrasses, conservation, distribution, Tropical Atlantic*

Introduction

Seagrasses are flowering plants belonging to the monocotyledonous angiosperms that grow totally submerged in the sea (Larkum *et al*., 2010; Bujang, 2012). These plants form meadows, considered one of the most productive, complex and ecologically important ecosystems (Bujang, 2012; Jayathilake & Costello, 2018). Seagrasses are subject to different threat factors (natural or anthropogenic origin) and its populations are one of the most threatened marine ecosystems (Waycott *et al*. 2009; Grech *et al*., 2012; Short *et al*., 2018).

There are different measures to preserve flora: *in situ* conservation strategies consist of preserving biodiversity in its natural environment or habitat (Aguilella *et al*., 2010; Rajpurohit, 2015), whereas *ex situ* conservation strategies consist of conserving biodiversity (or some of its components such as seeds, pollen or DNA) outside its natural environment (Jaramillo & Baena, 2002).

Over the years, and as a result of the socioeconomic development model, seagrass meadows of the Tropical Atlantic bioregion have been overexploited due to tourism, shipping, etc. This loss of habitat has been one of the reasons why concern and interest in marine conservation have increased.

In 2007, the IUCN carried out assessments of the conservation status of seagrasses, where it was analyzed their distribution, population dynamics, threats and conservation strategies. However, more than 10 years have passed since the last assessments, and during this period studies have continued to published, so that knowledge has probably advanced.

Therefore, the aim of this study is to conduct a review the current conservation status of endemic marine angiosperms in the Tropical Atlantic bioregion.

Materials and Methods

The methodology used in this study was based in the systematic review approach, followed by critical analyses of the obtained results. For the bibliographic search, different reputed scientific databases were used (Web of Science (WOS), Google Scholar, World Flora Online (WFO), IUCN Redlist, Global Biodiversity Information Facility (GBIF), Seed Information Database (SID) and PlantSearch).

The search strategy was based in the equation: (Seagrass* OR "marine angiosperm*") AND ("Halophila baillonii" OR "Halophila baillonis" OR "Halophila aschersonii" OR "Serpicula quadrifolia" OR "Halophila engelmannii" OR "Halophila ovalis" OR "Halophila johnsonii" OR "Barkania punctata" OR "Caulinia ovalis" OR "Halophila kotschyana" OR "Halophila kotschyanae " OR "Kernera ovalis " OR "Syringodium filiforme" OR "Cymodocea filiforme" OR "Cymodocea filiformis" OR "Cymodocea manatorum" OR "Phucagrostis manatorum" OR "Thalassia testudinum" OR "Thalassia vitrariorum") AND Atlantic AND (conserv* OR distribution OR population OR regres* OR declin* OR loss OR status OR habitat OR threat* OR ecology).

Furthermore, inclusion and exclusion criteria were applied to filter the most useful information for the analysis here presented.

Results and Discussion

The timeline of the analyzed studies showed that 2018 was the year with the highest number of works published. In general, there has been an irregular rate of publication on the subject under study, which suggests that the information will most likely be insufficient to draw robust conclusions about the conservation status of the species. *Thalassia testudinum* Banks & Sol. ex K.D.Koenig was the most studied species.

Both *Halophila* species analyzed (*H. baillonis* Asch. Ex Dickie and *H. engelmannii* Asch) were reported to have a discontinuous and poorly documented distribution (Hernández & Borges, 2017). The information of population dynamics is still insufficient, and both are fairly rare species within their distribution range, sometimes displaying fragmented populations (Magalhães *et al*., 2015; Madden *et al*., 2009). All this can make them more vulnerable to different impacts and hinders the implementation of appropriate conservation strategies, since population gene flow can be interrupted (Santos & Tellería, 2006; Quintero-Ángel *et al*., 2012).

The distribution and population dynamics of *Halophila johnsonii* Eiseman (synonym of the currently accepted *H. ovalis* (R.Br.) Hook.f.) are poorly documented. There still continues the controversy about the taxonomic identity between *H. ovalis* and *H. johnsonii*. It would be desirable to resolve this taxonomic issue (Hernandez & Borges, 2017) in order to achieve a better understating of the real situation on population dynamics, distribution, abundance, and threats, in order to design a more accurate conservation strategy for these taxa.

In contrast, *T. testudinum* has a well-documented distribution area. It is a dominant and most abundant seagrass in the Tropical Atlantic (Short *et al*., 2018). Its meadows take longer to recover after a negative impact, because it is a slow-growing species (Kenworthy *et al*., 2018). It is covered by 6 protection

figures, and this is because a broad knowledge of the species can make it easier to establish conservation measures. In addition, there is the presence of it in a germplasm bank.

The distribution of *Syringodium filiforme* Kütz. is poorly documented (Ruiz-Fernández, 2020), and there is insufficient information on its population dynamics. Its rapid vegetative growth allows it to take less time to recover after different impacts and helps to accelerate the restoration of other seagrass beds (Kenworthy *et al*., 2018; Furman *et al*., 2019). In addition, there is the presence of *S. filiforme* in a germplasm bank.

Conclusions

1. The results obtained on distribution, population dynamics, threats and conservation vary depending on the seagrass species. *T. testudinum* has been the most studied species. On the contrary, the rest of the species have a smaller number of studies and, above all, the information related to population dynamics is scarce and insufficient to obtain a broad view of their conservation status.
2. It would be desirable to carry out more in-depth taxonomic studies to determine the identity of *H. ovalis* and *H. johnsonii*. In this way, another series of more precise studies on distribution, population dynamics and threats, could be carried out, which would allow a good evaluation of the conservation status of each taxon.
3. In terms of *in situ* conservation strategies, *T. testudinum* is covered by more protection figures. Moreover, *ex situ* conservation strategies applied to Tropical Atlantic seagrasses are rather scarce. None of the species have seed banks, and only two of them (*T. testudinum* and *S. filiforme*) are in germplasm banks.
4. *H. baillonis* is the species to which the least conservation strategies have been applied, probably due to the fragmentation of its populations.
5. Tests and studies on the physiology of marine angiosperm seeds should be carried out to check their behavior in the face of desiccation. If they are recalcitrant, it would be interesting to try *in vitro* cultures, cryopreservation of plant cells and/or tissues or storage of other components in germplasm banks such as pollen, DNA, etc.

References

Aguilella, A., Fos, S., Laguna, E., (2010). *Catálogo valenciano de especies de flora amenazadas*, Colección Biodiversidad 18, Valencia: Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge, Generalitat Valenciana.

Bujang, J.S., (2012). *The Marine Angiosperms, Seagrass*, Serdang: Universiti Putra Malaysia Press.

Furman, B.T., Merello, M., Shea, C.P., Kenworthy, W.J., Hall, M.O., (2019). Monitoring of physically restored seagrass meadows reveals a slow rate of recovery for Thalassia testudinum. *Restoration Ecology* 27(2), 421–430. https://doi.org/10.1111/rec.12877

Grech, A., Chartrand-Miller, K., Erftemeijer, P., Fonseca, M., McKenzie, L., Rasheed, M., Taylor, H., Coles, R., (2012). A comparison of threats, vulnerabilities and management approaches in global seagrass bioregions. *Environmental Research Letters* 7(2). https://doi.org/10.1088/1748-9326/7/2/024006

Hernández-Albernas, J.I., Borges-Casas, C.C., (2017). Primer registro de la angiosperma marina Halophila ovalis en las Antillas Mayores. *Revista Mexicana de Biodiversidad* 88(4), 988–991. https://doi.org/10.1016/j.rmb.2017.10.030

Jaramillo, S., Baena, M., (2002). *Ex Situ Conservation of Plant Genetic Resources: training module*, Roma: Bioversity International

Jayathilake, D.R.M., Costello, M.J., (2018). A modelled global distribution of the seagrass biome. *Biological Conservation* 226, 120–126. https://doi.org/10.1016/j.biocon.2018.07.009

Kenworthy, W.J., Hall, M.O., Hammerstrom, K.K., Merello, M., Schwartzschild, A., (2018). Restoration of tropical seagrass beds using wild bird fertilization and sediment regrading. *Ecological Engineering* 112, 72–81. https://doi.org/10.1016/j.ecoleng.2017.12.008

Larkum, A.W.D., Orth, R.J., Duarte, C.M., (2010). *Seagrasses: Biology, ecology and conservation*, The Netherlands: Springer.

Madden, C.J., Rudnick, D.T., McDonald, A.A., Cunniff, K.M., Fourqurean, J.W., (2009). Ecological indicators for assessing and communicating seagrass status and trends in Florida Bay. *Ecological Indicators* 9(6), 68–82. https://doi.org/10.1016/j.ecolind.2009.02.004

Magalhães, K.M., Borges, J.C.G., Pitanga, M.E., (2015). Halophila baillonis ascherson: First population dynamics data for the southern hemisphere. *Anais Da Academia Brasileira de Ciencias* 87(2), 861–865. https://doi.org/10.1590/0001-3765201520140184

Quintero-Ángel, A., Osorio-Domínguez, D., Valenzuela, L., (2012). Algunas reflexiones sobre fragmentación y sus retos para la investigación. *Biodiversidad Neotropical* 2(1), 15–20

Rajpurohit, D., Jhang, T., (2015). In situ and ex situ conservation of plant genetic resources and traditional knowledge. *Plant Genetic Resources and Traditional Knowledge for Food Security*, 137–162. https://doi.org/10.1007/978-981-10-0060- 7_8

Ruiz-Fernández, A.C., Sanchez-Cabeza, J.A., Cuéllar-Martínez, T., Pérez-Bernal, L.H., Carnero-Bravo, V., Ávila, E., Cardoso-Mohedano, J.G., (2020). Increasing salinization and organic carbon burial rates in seagrass meadows from an anthropogenically-modified coastal lagoon in southern Gulf of Mexico. *Estuarine, Coastal and Shelf Science* 242, 106843. https://doi.org/10.1016/j.ecss.2020.106843

Santos, T., Tellería, J.L., (2006). Pérdida y fragmentación del hábitat: efecto sobre la conservación de las especies. *Oikos* 15(2), 3–12.

Short, F.T., Short, C.A., Novak, A.B., (2018). "Seagrasses", en: Finlayson, C.M., Everard, C.M., Irvine, K., Mclnnes, R., Middleton, B., van Dam, A., Davidson, N.C. *The Wetland Book*, Netherlands: Springer, 73–91.

Waycott, M., Duarte, C.M., Carruthers, T.J.B., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Short, F.T., Williams, S.L., (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences of the United States of America* 106(30), 12377– 12381. https://doi.org/10.1073/pnas.0905620106