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# Short Note
# Has *Halophila beccarii* Ascherson (Alismatales, Hydrocharitaceae) Been Locally Extirpated in the Philippines?

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The angiosperm genus *Halophila* Thouars is distributed in tropical and subtropical marine and estuarine habitats. Some species like *H. decipiens* Ostenfeld are widely distributed, being the only member of the genus showing a pantropical range[1], while other species like *H. hawaiiana* Doty & Stone and *H. johnsonii* Eiseman are rather restricted in distribution, confined only to the main Hawaiian islands and the southeastern coast of Florida, respectively[2].

Within the genus *Halophila*, *H. beccarii* Ascherson is recognized as a unique entity owing to its lack of cross veins in the leaf blades, among its most prominent features. Five sections within the genus have been recognized and *H. beccarii* is the only species placed under *Halophila* section *Microhalophila* due to its diminutive and delicate nature. It is primarily distributed on the shores of continental South and Southeast Asia, from western India in the farthest west of the range, on the Andaman Sea side of Thailand, Strait of Malacca, Gulf of Thailand, going north along the coast of Vietnam, to the region around Hong Kong as its easternmost reach[2]. Outside of continental Asia, a single site on Sarawak on the northwestern shore of Borneo was documented[2] where the type specimens of *H. beccarii* were collected near the mouth of the Bintula (=Bintulu?) River by Oeduardo Beccari, the intrepid Italian botanical collector and taxonomic authority on the Palmae of the last century. A single collection was also reported from the southwestern coast of Taiwan[3].

No documentation of *H. beccarii* from the Philippines was included in the last global compendium[2] although this has been reported by various authors[4-9]. All these records, however, can be traced to a single collection from Parañaque located on the southeastern shore of Manila Bay, collected by the American botanist Elmer Drew Merrill in 1911 and distributed in several herbaria. This habitat has since been reclaimed in the 1960s and became urbanized for the most part and any remaining populations of *H. beccarii* or any seagrasses would have been decimated in all probability. This may have led some workers to hypothesize that *H. beccarii* has been locally extirpated[10]. However there is disagreement on this point hinting that it still occurs in a few areas around Manila Bay and in the Lingayen Gulf on the northwestern coast of Luzon island without citing any herbarium voucher specimens[11]. Both localities though have been heavily impacted and have been the site of numerous incidents of fish kills due to intensive aquaculture and other anthropogenic activities in recent years[12]. Indeed, *H. beccarii* has been listed as among the three most vulnerable species of *Halophila* around the world together with *H. hawaiiana* and *H. baillonis* Ascherson in Hooker *fil*. (as *H. baillonii*)[13]. The shallower distribution of *H. beccarii* (max. 1 m deep) necessarily exposes it to greater risks compared to the other two which occur in greater depths.

The objective of this paper is to ascertain the current status of *H. beccarii* in the Philippines based on the examination of extant herbarium specimens as well as field surveys during the past ten years. Based on the information on the biology of *H. beccarii* in neighboring countries as well as our own field observations, evidence is presented to assess the current status of this species.

Herbarium specimens of *H. beccarii* deposited in different Philippine herbaria were searched. Literature describing the ecology and conservation status of the species as found throughout its distributional range was collated. Unfortunately, the search for *H. beccarii* in different herbaria has failed to produce any single sample. The three major Philippine herbaria searched are the Philippine National Herbarium (PNH) of the National Museum of Natural History in Manila, the Silliman University Marine Laboratory herbarium in Dumaguete City and the University of San Carlos herbarium (CEBU) in Cebu City. Numerous field surveys over the past ten years also yielded negative results.

*H. beccarii* was first reported from the shores of Parañaque on the southeastern fringes of Manila Bay at a time when mangroves were abundant and low-impact artisanal fishing activities were common[4]. A prominent coastal village in Parañaque at that time was Baclaran, which in Tagalog language means "place where bamboo fish corrals are found." Today, Baclaran is a highly populated village of 28,385 people in an area comprising only 63.72 ha, or a population density of 445.46 $ha^{-1}$ (http://www.paranaquecity.com/statistics.html). The coastal areas off Parañaque and adjacent points to the north and south have been subjected to large-scale land reclamation projects in order to meet the demands for more land as the metropolitan city of Manila expands. There are no longer mangroves in the area except for some strips of reforested mangrove stands adjacent to dense human settlements offshore. Artisanal fisheries have long been replaced by commercial trawling.

*H. beccarii* is usually restricted to the intertidal mudflats often with mangroves nearby[14]. The same habitat has been described for *H. beccarii* in many parts of India[15] and other sites in continental Southeast Asia[16]. This narrow zone of occurrence close to sources of anthropogenic disturbance makes this species particularly vulnerable. While muddy substrates within mangrove forests are the most preferred habitats similar to those observed by the authors at the mangroves of Sungei Buloh National Park in Singapore, *H. beccarii* have been reported growing on sandy substratum and down to a depth of 1.7 m. Apparently the type of substrate affects some growth parameters of *H. beccarii*. In a survey of seagrasses from Bintan Island in the Riau Archipelago (Indonesia) only 2 h away from Singapore, no *H. beccarii* was documented owing to the predominantly sandy reef substrates there[17], considering that this species has been found in significant numbers of patches around the main island of Singapore such as in Chek Jawa and Sungei Buloh (unpublished data). These localities, while probably being impacted by anthropogenic activities, are subjected to some degree of freshwater influx from rivers draining into the narrow Johore Straits from peninsular Malaysia.

The type of substrate apparently affects the distribution and density of seagrasses especially for *H. beccarii* which has an extremely narrow vertical distribution (depth range) of ca. 1 m for the most part[13]. Comparing the shoot density of populations growing on muddy and sandy substrata, it was found that shoot density of *H. beccarii* increased significantly in southeastern Indian muddy habitats (6,152 shoots $m^{-2}$) compared to that in sandy substrates (3,632 shoots $m^{-2}$), with corresponding total biomass increases of more than quadrupled values in muddy substrates (25.5 g $m^{-2}$) as opposed to those in sandy bottoms (6.2 g $m^{-2}$)[15]. The same highest shoot density and biomass were documented during the dry months of January to March in Bangladesh[18]. An extreme situation reporting 9 ha of *H. beccarii* off Donghai Island in western Guangdong province in China was documented[19], although no biomass figures were available. Farther west of Donghai Island, a high shoot density of nearly 6,000 shoots $m^{-2}$ for *H. beccarii* in Liusha Bay[19]. Clearly, *H. beccarii* is a highly substrate-specific as well as a distinctly seasonal species. Perplexingly though, only a single collection of *H. beccarii* was made during a multi-year survey conducted along the entire 2,279 km coastline of Myanmar which may have estuarine habitats suitable for this species[20].

It has been suggested that *H. beccarii* is a rather sensitive species as it disappears quickly when unfavorable environmental conditions occur, but which is compensated by a high fecundity rate and an ability to grow their rhizomatous systems fast enabling them to colonize suitable substrates within a short time[21]. It is probably quite specialized in its habitat choice growing in sites where other species cannot survive. In fact, among the habitats in southern Thailand surveyed, only *H. beccarii* and such hardy species as *H. ovalis* (R. Brown) Hooker *fil.* and *Enhalus acoroides* (L. *fil.*) Royle have been observed near river mouths where freshwater influx and sedimentation are common[22]. The latter causes light penetration to decrease affecting photosynthetic performance among phototrophs there.

There have been many reports of flowering periods of *H. beccarii* from throughout its known distributional range, but these reports are often conflicting. Clearly the flowering phenomenon in *H. beccarii* is influenced by local conditions more than genetic factors. One report found flower production under conditions of low salinity (5.38 ‰) coupled with low phosphate and high nitrate values[23]. In a study determining the factors affecting flowering and fruiting in *H. beccarii* from Malaysia, it was found that air temperature had the most profound effect[24]. Flowers were most abundant when air temperatures were low (25.5-26.0°C in January). The study, however, does not give a hint about emersion time nor the extent of shade at the site. In the Sungei Buloh National Park in Singapore, high biomass of *H. beccarii* was observed by the authors under the canopy of mangroves and in habitats subjected to constant emersion and immersion. In this habitat, populations were observed to grow on small mud mounds each one surrounded by substrata usually without vegetation. These mounds were apparently slightly elevated muddy substrates retained by the rhizome systems of the seagrass growing upon them when the surrounding space has been eroded by tidal action.

The seed coat morphology of several *Halophila* species from East Malaysia and Mauritius has been compared[25]. The testa were found to have reticulations of distinct configurations ranging from rectangular to hexagonal, sometimes with small peg-like projections issued from the reticular space, features that may be useful taxonomic characters. These reticulations and projections are said to increase the surface area of the seeds which would help them to become buoyant by increasing their surface area to volume ratio. In addition, air bubbles might also be trapped within these reticulations adding to their buoyancy. Interestingly, however, despite the ornate reticulations found on the seed coat of *H. beccarii*, seeds are negatively buoyant[24]. This negative buoyancy may be an important constraint towards long distance dispersal and may be one important factor to explain the localized geographic distribution of this species.

Temperature plays an important role in the distribution of *Halophila* species just as it regulates the geographic distribution of most marine organisms. However, no available data on the effect of temperature on *H. beccarii* can be found in the literature.

Salinity appears to have a profound effect on the distribution of *H. beccarii* throughout its known distributional range. The original type specimen of *H. beccarii* was found near a river mouth in Sarawak where freshwater influx was significant causing a diluting effect on the seawater there. The same ideal estuarine habitats have been reported as hosting healthy populations of *H. beccarii* as in the case of southern Thailand[22] and in mangroves with estuarine conditions in India[14, 15]. In the small island nation of Singapore, there existed a north-south dichotomy in the distribution of seagrasses, which may be attributed to salinity differences between the northern and southern coasts[26]. *H. beccarii* has only been reported along the northern coasts which are under the influence of freshwater input from mainland Malay Peninsula while the same species was virtually absent along the southern coasts and offshore islands farther south where conditions are marine. It is noteworthy that within Southeast Asia, specimens were encountered in greater number along the estuarine coasts of continental land mass compared to coastal areas of insular countries (e.g., Indonesia, the Philippines). This is because there are several larger river systems on the continental Southeast Asia draining southward creating large deltas and extensive swamp lands that provide ideal growing conditions with reduced salinity. This is not the case with insular locations in Southeast Asia where river systems are often smaller, shorter and with a lesser river water output into the marine environment. The same could be said of the Indian Subcontinent wherein an extensive survey of *H. beccarii* reported healthy populations on the mainland[27] except for a single record from the offshore Andaman Islands where it was found on mudflats[28].

In the Philippines, estuarine habitats such as mangroves and river mouths are under severe threat from human activities. Some of these threats include the conversion of estuarine mangrove habitats into shrimp aquaculture farms[29], upland deforestation which contribute to the loss of forest top soil causing massive soil erosion, mining activities that release toxic mine tailings without regard for existing regulations, unsustainable agricultural practices that contribute to the nutrient load in natural waterways leading to eutrophication, coastal development and waste generation and others[13]. These and other factors have contributed to the degradation of many brackish water habitats in the Philippines, threatening many estuarine organisms including *H. beccarii*.

The survival of *H. beccarii* also hinges on its genetic and reproductive characteristics. Populations of *H. beccarii* at its northernmost range off southern China[30] and in central Vietnam[31] were found with low genetic diversity and high clonality further sounding alarm bells to its vulnerability to global climatic changes and human pressures. This is also exacerbated by the poor protection afforded to seagrass habitats where *H. beccarii* may be an insignificant component. But all hope is not lost. Recruitment through sexual reproduction, though less common than clonal growth, can potentially provide avenues for local, short-distance dispersal of seeds[31] despite the fact that seeds are negatively buoyant[24].

Critical habitat conditions in many estuarine habitats pose various levels of extinction threats on such fragile and minute species as *H. beccarii*. Even larger and presumably more resilient species have experienced rapid decline throughout the western Pacific[32]. Today, *H. beccarii*, commonly known as the ocean turf grass, has been classified as Vulnerable in the IUCN Red List of Threatened Species version 2017-3[33]. Given the high threat levels in suitable habitats in the Philippines, it is conceivable that it has been extirpated locally.

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