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Short Communication

A first record of *Halodule pinifolia* Miki den Hartog, and new locality of nationally endangered *Halophila beccarii* Asch, from the eastern coast of Sri Lanka

Susantha Udagedara*, Daniel Fernando, Nishan Perera, Akshay Tanna, Rosalind Bown

Blue Resources Trust, No. 86 Barnes Place, Colombo 7, Sri Lanka.

Abstract: This study presents the first record of *Halodule pinifolia* on the eastern coast of Sri Lanka, approximately 310 km along the coastline from the previously recorded location (Kapparathota, Weligama). Further, this study describes the new locality of the nationally endangered seagrass species *Halophila beccarii* to Valaichchenai Lagoon, 26.5 km north of Batticaloa Lagoon, where it was previously recorded, along with the presence of two other species, *Halophila ovalis* and *Halodule uninervis*. While the species composition the seagrass habitat of Valaichchenai Lagoon might change in the near future due to the impact of climate change, multiple threats already exist at these newly discovered seagrass habitats, including multiday fishing vessel movements, the collection of shells on the seagrass beds, and solid waste dumping into the lagoon. Decline of seagrass abundance in Valaichchenai Lagoon would negatively impact the food security and income generation of fishers. Therefore, a well-established legislative framework and systematic long-term monitoring of seagrass in Valaichchenai Lagoon are essential in order to develop seagrass conservation plans before populations decline significantly or become locally extinct.

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Introduction

Seagrasses are an extensively distributed group of marine flowering plants having a relatively low number of species in the world (72) that are often overlooked due to their submerged environment (Short et al., 2007; Short et al., 2011). Seagrass has been identified as one of the most productive ecosystems, second to mangroves and coral reefs (Nadiarti et al., 2012). Therefore, seagrasses are ecologically and economically important due to the ecosystem services and functions they perform, specifically in relation to atmospheric carbon absorption in mitigating climate change (Fourqurean et al., 2012; Kumara and Udagedara, 2012). Unfortunately, estimated annual loss of this valuable species may be as high as 7% of their total global area since 1990 (Serrano et al., 2016). This is due to shifts in water quality, increased loading of sediment, contaminants, poor land management, nutrients, coastal development, impact from global climate change, and other changes, and fisheries over-exploitation (Orth et al., 2006; Coles et al., 2011; Nadiarti et al., 2012).

The tropical Indo-Pacific represents one of the highest seagrass bioregions in the world, accounting for around 35% of total species (Short et al., 2011). However, this region also has extensive gaps in knowledge related to seagrass distribution and species, accounting for around 24% data scarcity (data deficiency), particularly for population data (Short et al., 2011). Sri Lanka is located in the Indo-Pacific bioregion. So far fourteen species belonging to six genera (60% of the Indo-Pacific bioregion seagrasses) have been recorded there: *Enhalus acoroides*, *Halophila beccarii*, *H. decipiens*, *H. ovalis*, *H. ovata*, *H. minor*, *H. stipulacea*, *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, *H. pinifolia*, *Ruppia maritime* and *Syringodium isoetifolium* (Udagedara in preparation). The species *H. stipulacea* was recently added to the

*Corresponding author: Susantha Udagedara
E-mail address: susantha@blueresources.org
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seagrass species list in Sri Lanka (LK6-2132-ORAKA).

In Sri Lanka, seagrasses are found primarily in shallow, sheltered marine and estuarine waters on sandy, salty, or clay substrate in the Gulf of Mannar, the lagoons around the Jaffna Peninsula and Puttalam, the Negombo estuary, Weligama, Mulathivu, Trincomalee, Chilaw Lagoon, Batticaloa Lagoon, Mawella Lagoon, Koggala Lagoon, Mullaitivu, Valaichchenai Lagoon (Abeywickrama and Arulgnanam, 1991; Udagedara in preparation). Since propagules are transferred by ocean currents and have a wide distribution pattern across coastal habitats (Abeywickrama and Arulgnanam, 1991), no species is endemic to Sri Lanka (Abeywickrama and Arulgnanam, 1991). Distribution records of seagrasses for the eastern part of Sri Lanka are extremely limited, and mostly only available prior to 1990 due to the three-decade civil conflict that prevailed in this area until 2009. There is some information on seagrasses for the southern coast of Sri Lanka, but this data is also limited due to lack of research (Silva et al., 2013; Udagedara et al., 2017; Udagedara et al., unpublished). Information on population declines is also insufficient, however Silva et al. (2013) highlighted a decline in the standing crop of seagrass ecosystems to be around 96% in the northern, eastern and western parts of Negombo Lagoon between 1997 and 2004. In addition, around 20% of the total seagrass cover in Negombo Lagoon has been lost owing to pollution and micro-algal proliferation on seagrass beds as a result of nutrient loading (Joseph, 2011). Therefore, it is highly likely that similar declines may be affecting other areas given similar anthropogenic impacts, suggesting that national declines may be very high and be likely to lead to extirpations before proper documentation is in place.

Halodule pinifolia has to date been recorded in a total of four localities from the northern, western, and southern parts of Sri Lanka: 1991 and 1996 in Negombo Estuary (Abeywickrama and Arulgnam, 1991; Pinto and Punchihewa, 1996); 2011 in Kapparathota, Weligama (Bandara et al., 2011); 2014 in Mannar (ISEA, 2014); and 2016 in Mandaitheevu, Jaffna Lagoon (Digamadulla et al., 2016). This species' prominent characteristics include rhizome creeping with 2-3 roots and a short erect stem of 1-3 cm length at each inter node. Its blades are 5-20 (-29) cm long and (0.03-) 0.06-0.125 (-0.15) cm wide, with apex rounded with minute serrations and two poorly developed to non-existing lateral teeth. However, *H. pinifolia* is often confused with narrow-leaved *H. uninervis* which can be distinguished by blade apex morphology (Abeywickrama and Arulgnanam, 1991; Kuo and den Hartog, 2001). The IUCN Global RedList has categorized this as a species of Least Concern with a declining population trend (Short et al., 2010b).

The seagrass *H. beccarii* is commonly known as ocean turf grass. It has a thin rhizome with two scales covering the base of the erect stem and a group of 4-12 leaves at the top. The blades are lanceolate, up to 13 mm long, 1-2 mm wide, with no cross veins, apex pointed. The lack of cross veins is a unique character among genus *Halophila* (Abeywickrama and Arulgnanam, 1991; Kuo and den Hartog, 2001). *Halophila beccarii* is categorized as endangered according to the 2012 National Red List and Vulnerable by 2011 global IUCN Red List as it is rare in nature, and when encountered only occurs in fragmented populations (Short et al., 2010a; MEO, 2012). Due to its specific habitat requirements and narrow depth range, its global area of occupancy has been estimated to be less than 2,000 km² (Short et al., 2010a). To date this species has only been recorded in four localities in Sri Lanka: in 1885 and 1991 at Batticaloa Lagoon (Dassanayake et al., 1995); in 1932 at Muthur, south of Trincomalee (Dassanayake et al., 1995); and in 1991 and 2003 at Negombo Estuary/Lagoon (Samarakoon and Van Zon, 1991; Abeywickrama and Arulgnanam, 1991).

These biologically important seagrass ecosystems have not been studied over a long period of time, and there are considerable information gaps, particularly for the eastern coast of Sri Lanka. This paper presents some new data that can help fill in some of these information gaps, which it is hoped will provide a

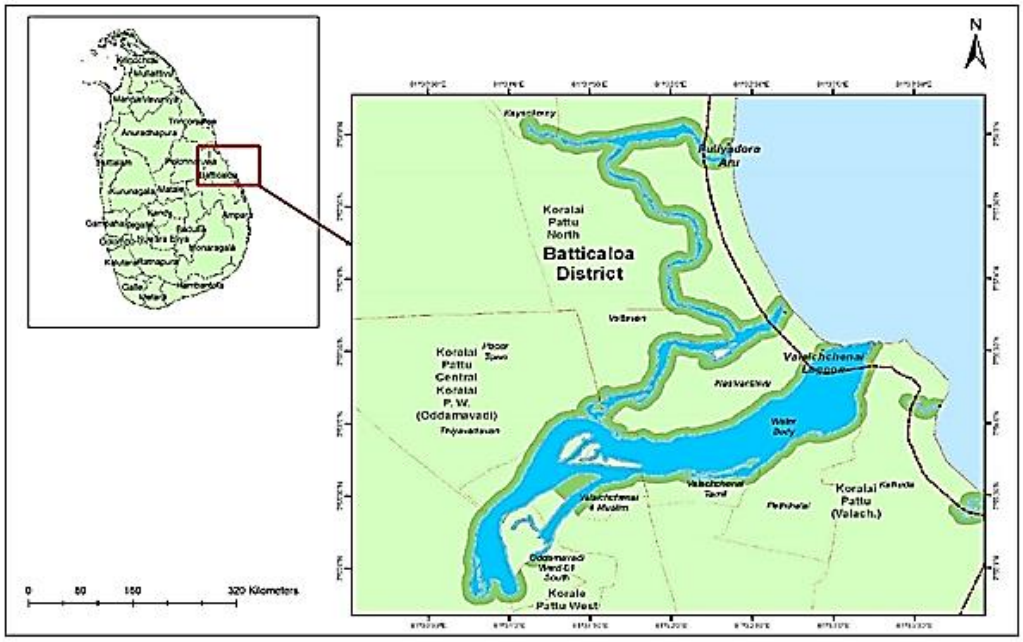

Figure 1. Map of Valaichchenai Lagoon, Batticaloa District, Sri Lanka.

baseline for future research.

Methods

Valaichchenai Lagoon is situated between 81.548952-7.941750 and 81.554221-7.942600 in the vicinity of Passikudah Bay in the Batticaloa District of Sri Lanka, encompassing an area of about 13.21 ha (Silva et al., 2013) (Fig. 1). According to Punyawardena. (2008), the lagoon area belongs to the Dry Low Country (DL_{2b}) Agro Ecological Zone with less than 200 mm of mean annual rainfall. Silva et al (2013) categorized the lagoon as having the highest index of annual fresh water influx per unit area (0.665 $Mm3ha^{-1}yr^{-1}$) although it is located in the dry zone, largely due to large amounts of fresh water diverted from the Maduru Oya River together with the comparatively small size of the lagoon itself.

Preliminary observations, personal discussions with local communities (fishers) and personal communications with experts including fishery inspector were carried out to determine potential areas of distribution of seagrass meadows within the Valaichchenai Lagoon. In May 2017, rapid seagrass sampling surveys were conducted covering all habitat types in the lagoon. A random vegetation sampling method using a 50x50 cm^2 quadrate (Burdick and Kendrick, 2001; McKenzie et al., 2001) was conducted on 50 m parallel transects with 5 m intervals between each transect. Seagrass sampling and photography of each quadrat was done while skin diving. Collected specimens were identified based on the key developed by Abeywickrama and Arulgnam, (1991) and Kuo and den Hartog, (2001). Herbarium specimens of each species were collected, pressed and independently coded by members of the research team, with species identification verified in consultation with a globally recognized seagrass taxonomist. Specimens were deposited in the National Herbarium in Peradeniya (PDA), Sri Lanka, under voucher numbers BRT/SG/SL/NE/VC/001 to 004. Anthropogenic impacts were recorded through personal observations and discussions with local communities adjacent to the sampling area.

Results and Discussion

Results of the rapid seagrass sampling indicated that seagrasses were distributed along both sides of Valaichchenai Lagoon, and extending inland approximately 2 km from the lagoon mouth, including a lagoon branch, Nasivanthivu to Puliyadora Aru (~5 km). Seagrass occurrence tended to be patchy, ranging from sparse growth to extensive meadows. A total of four species of seagrass were recorded during the surveys, namely: *Halophila beccarii*, *H. ovalis*,

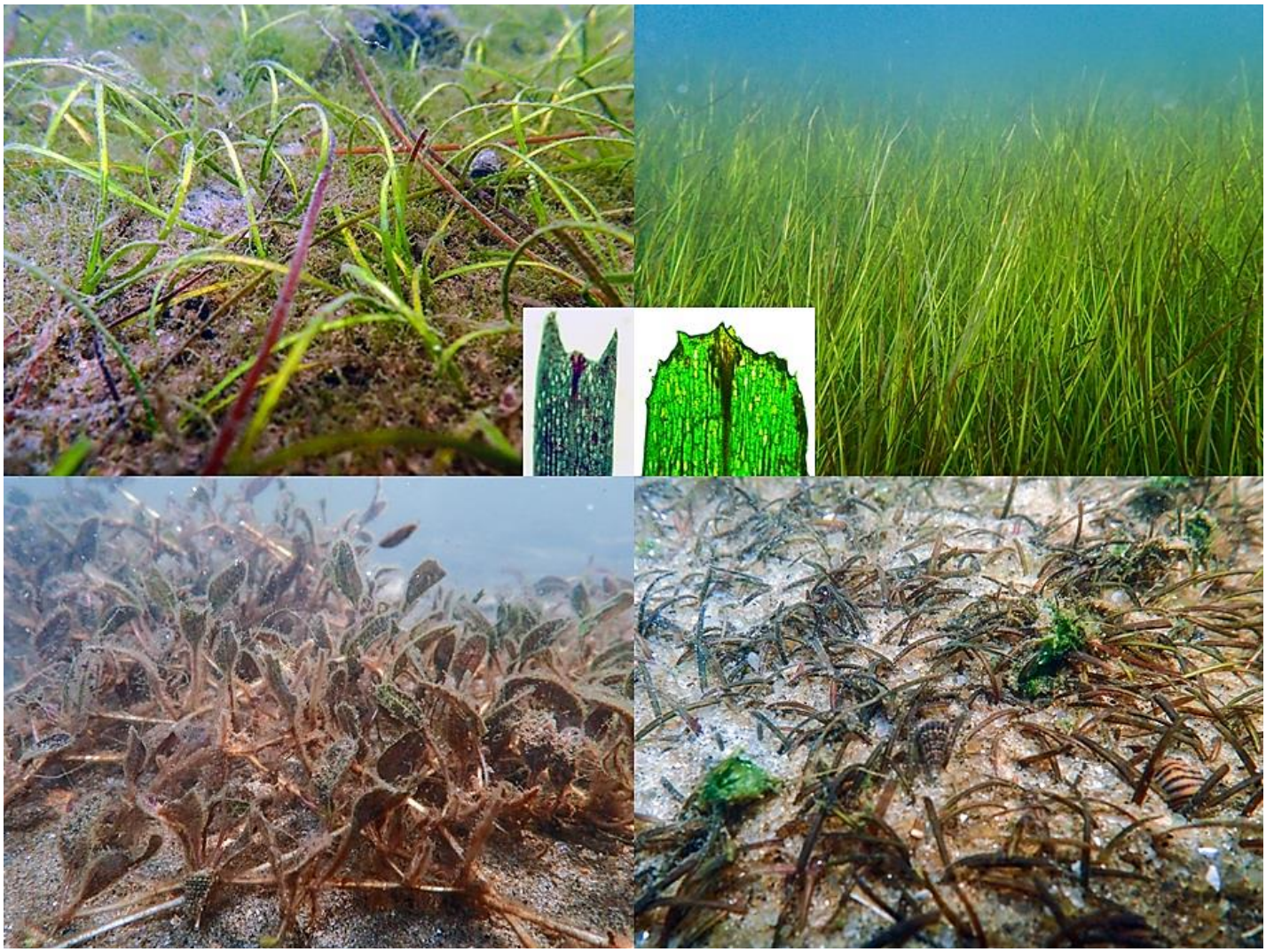

Figure 2. Clockwise from upper left: *Halodule uninervis*, *Halodule pinifolia*, *Halophila beccarii* and *Halophila ovalis* (Photo copyright: Susantha Udagedara).

Halodule uninervis, and *H. pinifolia* (Fig. 2). The species composition and distribution pattern showed similarities to that of the Negombo Estuary described by Samarakoon and Van Zon (1991).

The record of *H. pinifolia* from Valachchenai lagoon is the first record of this species from the east coast of Sri Lanka, with previous records being confined to the west coast in Weligama, the Negombo Estuary, Mannar, Mandaitheevu, and Jaffna Lagoon (Fig. 3). *Halodule pinifolia* is the most widely distributed species in the main lagoon of Valachchenai, but does not extend in to the peripheral lagoon (Nasivanthivu to Puliyadora Aru). Closer to the lagoon mouth, *H. pinifolia* was found together with other recorded species. High numbers of epiphytes in *H. pinifolia*'s blades were observed in the area where it was located close to mangrove patches and shallow, muddy substrate. The abundance of *H. pinifolia* was similar to that in the Negombo Estuary, and may be due to species-induced high physicochemical tolerance limit and the high index of annual fresh water influx per unit area of both lagoon (De Silva and Amarasinghe, 2007; Silva et al., 2013).

Halophila beccarii was recorded on both sides of the lagoon and towards the lagoon mouth up to approximately 1.5 km as a small, scattered, patchy population. *Halophila. beccarii* was mainly found in sandy or muddy substrate, and in some locations mixed with *H. ovalis*, *H. uninervis* (similar to the observations of Kanal and Short (2009)) and *H. pinifolia*. Different leaf morphology was observed during the study and narrow leaf blades were observed

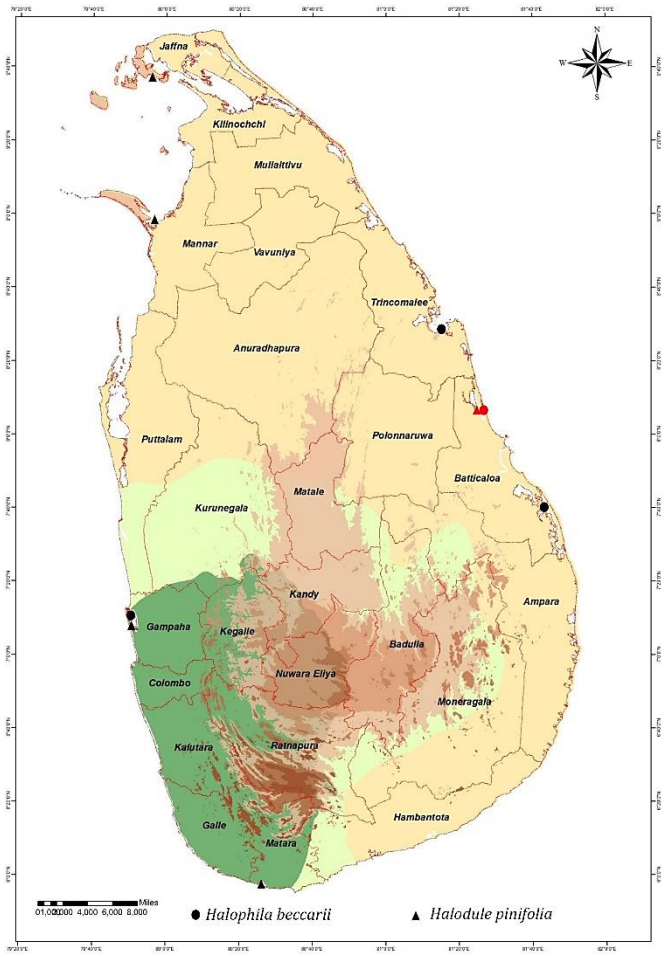

Figure 3. Distribution map of *Halodule pinifolia* and *Halophila beccarii* (Red circle and trundle indicates a new record)

in shallow areas where tidal action was high (~15 to 30 cm), while wide leaf blades were identified in areas where water depth was comparatively high (~30 cm to >1 m).

Scattered *H. ovalis* populations were found in the main lagoon on predominantly sandy substrate, and in certain areas overlapping with other species. Only *H. ovalis* was widely distributed along both sides of the peripheral lagoon (Nasivanthivu to Puliyadora Aru ~5 km). However, it was observed that the majority of *H. ovalis* was present in shallower water, and in areas where it grew exclusively, the leaves had more red color pigmentation. Sidik et al. (2010) highlighted that this might be due to UV-blocking pigments that protected these plants when exposed to direct sunlight during low tides. However, in mixed populations they had lower levels of red pigmentation as they were partially protected by species of *Halodule* that attained greater vertical relief and provided some degree of shading.

Valachchenai Lagoon is heavily impacted by anthropogenic activities that threaten seagrasses, other coastal ecosystems and associated species. The lagoon is an important anchorage for fishing boats with a fisheries harbor located ~3.1 km inside the lagoon. The wake caused by the constant movement of boats through the lagoon can have negative impacts on seagrasses. This newly discovered habitat is very vulnerable due to various anthropogenic impacts including wake impacts of multiday boats (120 to 300 boat movements per week depending on season-fisheries inspector at Valachchenai harbour) entering the lagoon to access the fishery harbor from the lagoon mouth. The center of the lagoon has been dredged to facilitate boat movement and may have resulted in the loss of seagrass habitat, and is the likely reason that no seagrasses were observed in the middle part of the lagoon. Significant threats to the lagoon ecosystem include the collection of shells on the seagrass beds; indiscriminate disposal of solid waste into the lagoon; oil and chemical pollution from fishing boats; lagoon encroachments; anchoring of boats on seagrass beds; the use of outboard motors in shallow seagrass areas; the use of harmful fishing gears such as monofilament gill nets and drag nets. Further, other recorded impacts were sedimentation and agricultural runoff from upriver sources. Santharooban et al. (2012) recorded higher than accepted levels of nitrogen and phosphorous being discharged into Valachchenai lagoon from the fisheries harbor, paper mill, rice mills, and shrimp farms. This may lead to eutrophication, which would result in the degradation of seagrass habitats within the lagoon (Miththapala, 2008).

Conclusion

This study documents the first record of *H. pinifolia* from the eastern coast of Sri Lanka, and provides a new locality of the globally vulnerable *H. beccarii*. The presence of *H. beccarii* is significant as this species has diminished in other areas of Sri Lanka. For example, De Silva and Amarasinghe (2007) reported the extirpation of this species at the same locations in

Negombo Estuary from where it was previously recorded by Jayasuriya (1990). It is important that adequate management is carried out to prevent similar outcomes at Valachchenai Lagoon, where increasing anthropogenic impacts may result in severe population declines or extirpation in the near future.

Silva et al. (2013) estimated that the average monthly income for fishers in Valaichchenai Lagoon was LKR 17,000.00 (130.1 USD-conversion rate 130), which is LKR 1 4,441.00 of average monthly income of the Sri Lankan fishers. Unsworth et al. (2014) highlighted the importance of seagrasses for high fisheries production due to their value as a critical nursery habitat. Therefore, a decline of seagrass in the Valaichchenai Lagoon would negatively impact food security and income generation of artisanal and subsistence fishers. Seagrass species composition and habitat of this lagoon may change due to anticipated climate change impacts in the future including increasing sea-surface temperature, rising sea levels, and other disturbance regimes highlighted by Waycott et al. (2007). Results from this study will help in the development of long-term monitoring programs and management strategies that take into account available information on the ecological biogeography of the population in addition to impacts from anticipated climate induced shifts. This data can also be fed into the mechanisms that enable the updating of the IUCN Red List status of these species for future conservation decision-making. It is also of note that although around 72 countries have some form of seagrass management or protection via various mechanisms, Sri Lanka is yet to develop dedicated management plans or legislation for the protection of seagrass. Developing sound legal mechanisms is essential for the management of this critical habitat (Unsworth and Cullen-Unsworth, 2014), and it is hoped that this and other ongoing research will contribute to the improved management of seagrass habitats in Sri Lanka.

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