TAP CHI SINH HOC 2017, 39(4): 434-450
DOI: 10.15625/0866-7160/v39n4.10082

THE STATUS OF INVASIVE PLANTS AND ANIMALS IN CU LAO CHAM BIOSPHERE RESERVE, QUANG NAM PROVINCE, VIETNAM

Vu Anh Tai, Uong Dinh Khanh, Luu The Anh, Le Thi Thu Hien

Institute of Geography, VAST

ABSTRACT: The biodiversity of Cu Lao Cham Biosphere Reserve (Hoi An City, Quang Nam Province) has been faced with some passive impacts, one of which is invasion/expansion of alien species. In 2017, according to the data of GISD, CABI and the Inter-ministerial Circular No.27/2013/TTLT-BTNMT-BNNPTNT, based on filed survey conducted in May, 19 alien plant and 3 alien animal species were recorded in the biosphere reserve. Among them, 13 plant species were identified as invaders, of which details were assessed in this study; among those invader plants, 3 species were ranked at medium risk and the 10 others were ranked at low risk. All of the medium risk-invasive plant species have been appeared on the islands but one of them, siam weed (*Chromolaena odorata*), was not identified as impacting to the mainland of the biosphere reserve. Likewise, all of the alien animal species have been not recognized as the invasive species. In general, the impact of alien species found in the Cu Lao Cham was assessed as "Low Risk". The impact status of invasive species in the Hoi An mainland part is more serious than the situation in the islands. Base on the results, we suggest that, five species, beggar-ticks (*Bidens pilosa*), coast morning glory (*Ipomoea cairica*) Bay Biscayne creeping-oxeye (*Sphagneticola trilobata*), Blue porterweed (*Stachytarpheta jamaicensis*) and billygoat-weed (*Ageratum conyzoides*) should be added in the invasive appendix of the national invasive species list while three other species as vilfa stellata (*Cynodon dactylon*), guava (*Psidium guava*) and rose myrtle (*Rhodomyrtus tomentosa*) should be listed in the potential appendix of that list. It is necessary to conduct some survey to obtain solution to control invasive species as soon as possible to protect the biodiversity of this study area.

Keywords: Alien species, invasive, biosphere reserve, Cu Lao Cham, GISD, ISC, Inter-ministerial Circular No.27

Citation: Vu Anh Tai, Uong Dinh Khanh, Luu The Anh, Le Thi Thu Hien, 2017. The status of invasive plants and animals in Cu Lao Cham biosphere reserve, Quang Nam province, Vietnam. Tap chi Sinh hoc, 39(4): 434-450. DOI: 10.15625/0866-7160/v39n4.10082.

**Corresponding author:* tai.botany@gmail.com

Received 15 June 2017, accepted 12 December 2017

INTRODUCTION

A variety of plants, fungi, or animals that are not native to a specific location are considered as invasive species, which tend to spread and cause damage to the environment, human economy or human health. Thus, the information about invasive species have been recognized and shared by a lot of specialists over the world who established a consortium of the Invasive Species Specialist Group (ISSG), a global network of scientific and policy making experts on invasive species, organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) in 1994. The ISSG aims to reduce threats to natural ecosystems and the native species they contain by increasing awareness of invasive alien species, and of ways to prevent, control or eradicate them. Currently, the Global Invasive Species Data (GISD) is managed and published by this group that have been commonly used all over the world wherever an invasive species has found among native distribution or alien/impacted range and the experience to manage them (ISSG, 2015). In 2001, the Centre for Agriculture and Biosciences International (CABI) developed the Invasive Species Compendium (ISC) as an encyclopedic resource that draws together scientific information on all

aspects of invasive species (CABI, 2017). The ISC is an online, open access reference work covering recognition, biology, distribution, impact and management of the world's invasive plants and animals. Using ISC together with GISD, people can identify any organism is an invader or not.

Vietnam is a tropical country with rich biodiversity, including 2393 non-vascular plants and 11,373 vascular plants (VAST & CRES, 2005). Among those, 882 species including 418 animal and 464 plant species are listed in the Vietnam Red Data Book (VAST & MONRE, 2007). However, the nature habitats and threatened species in the country have been facing with a lot of pressures and risks. One of the important pressures is invasive organisms.

Dang Thanh Tan et al. (2012) reported invasive plants from national parks in Vietnam and found 134 alien species. After assessment, 25 of them were determined as invasive plants. They assessed for 10 national parks but field survey was conducted at 4 of them only. In their study, the species were determined to be Invasive Alien Species (IAS), Likely Invasive (L.IAS) or Potentially Invasive (P.IAS) based on the criteria described by the Massachusetts Invasive Plant Advisory Group.

On 26th September 2013, the Ministry of Nature Resources and Environment (MONRE) together with the Ministry of Agriculture and Rural Development (MARD) had jointly stipulated Inter-ministerial Circular No. 27/2013/TTLT-BTNMT-BNNPTNT (Circular No. 27), to provide the criteria for determination of invasive exotic species and promulgating the list of invasive exotic species (MONRE & MARD, 2013).

Cu Lao Cham (CLC) biosphere reserve, also known as Cu Lao Cham Marine Park, is located on the Vietnamese East Sea under the administration of Tan Hiep Commune and Hoi An Town, in Quang Nam Province, Vietnam. The surface area (terrestrial and marine) of the CLC is 33,146 ha that includes 2,471 ha of the core area (terrestrial: 257 ha; marine: 2,214 ha); 8,455 ha of the buffer zone (terrestrial: 2,410 ha; marine: 6,045 ha) and 22,220 ha of the transition area (terrestrial: 3,523 ha; marine: 18,697 ha) (UNESCO, 2010). The terrestrial and coastal ecosystems of the islands have been recognized as a global Biosphere Reserve by UNESCO on 26 May 2009 under its 'Man and the Biosphere Programme' for its rich biodiversity value (UNESCO, 2010). The ecosystem also includes the ancient Hoi An, which is 20 km away from the islands, a UNESCO World Heritage Site. The biosphere reserve's area covers 5,000 ha including 165 ha of coral reefs and 500 ha of underwater plant life.

The rich biodiversity of CLC comprises both terrestrial and aquatic marine ecosystem (UNESCO, 2015). In CLC, the major terrestrial ecosystem components are: "the sea grass beds, seaweeds, coral reefs, mangroves, tropical rainforests and others" and the major habitats are "Forest, sea beaches, rocky hills and mountains, rice and other cultivation, grass fields and others". The terrestrial resources consist of the traditional resources extracted from the islands by the Cham people of the islands. These comprise rice farming, trading in pepper, cinnamon bark, ivory and wood for trading with neighboring countries, accessed through the port of Hoi An. There are two core areas, long-term and concentrative conservation are strongly focusing on land/seascape diversity in order to conserve the ecosystems, habitats, species and genetic resources, and to preserve the intactness of the ecosystems, the wild areas from the upset made by people. The corridor between two core areas is considered as the ecological buffer and transition areas linking the River mouth (Cua Dai) and the archipelago outside. This zone contributes a lot to recover the marine ecosystems in the whole area.

Biodiversity values of CLC: At ecological level, the lowland evergreen forest there plays a very important role of water resources protection for the whole islands. In addition, the vegetation at some rocky areas is also an ecological niche for some valued birds, such as swallow and salangaes (UNESCO, 2015). At species level, according to the Vietnam Red Data Book (VAST & MONRE, 2007), there is one threaten plant species as *Mitrephora calcarea* (Annonaceae family) that is growing

in the closed tropical evergreen forest. According to the UNESCO report (UNESCO, 2015), there are 947 kinds of creatures living around the marine area of the islets, including 178 species of fish, 122 species of seaweed, 134 species of coral, 144 species of shellfish, 25 species of crustacean and many other marine species. Characteristic fish species include coral grouper (*Epinephelus coralicola*), bumphead parrotfish (*Bolbometopon muricatum*), angelfishes (Pomacanthidae) and the endangered hump head wrasse (*Cheilinus undulates*), etc.

Recently, because of development of tourism and infrastructure construction in a purpose to supported for both of national defense and tourisms, CLC is faced to expand the invasive plants. However, there are no reports mentioning about the invasive species or its impact occurring in the biosphere reserve. In purpose of conservation of and sustainable development implementation on the CLC, survey and assessment of invasive organism is necessary to conduct and suggest a suitable management or exploitation of those species.

MATERIALS AND METHODS

The methodology of surveillance for alien species was based on the common species biodiversity survey methods. A list of alien species in Vietnam was prepared before field survey was conducted. That list was prepared according to the GISD and ISC with impacted/impacting species to Vietnam and other species were cited from the Circular No. 27.

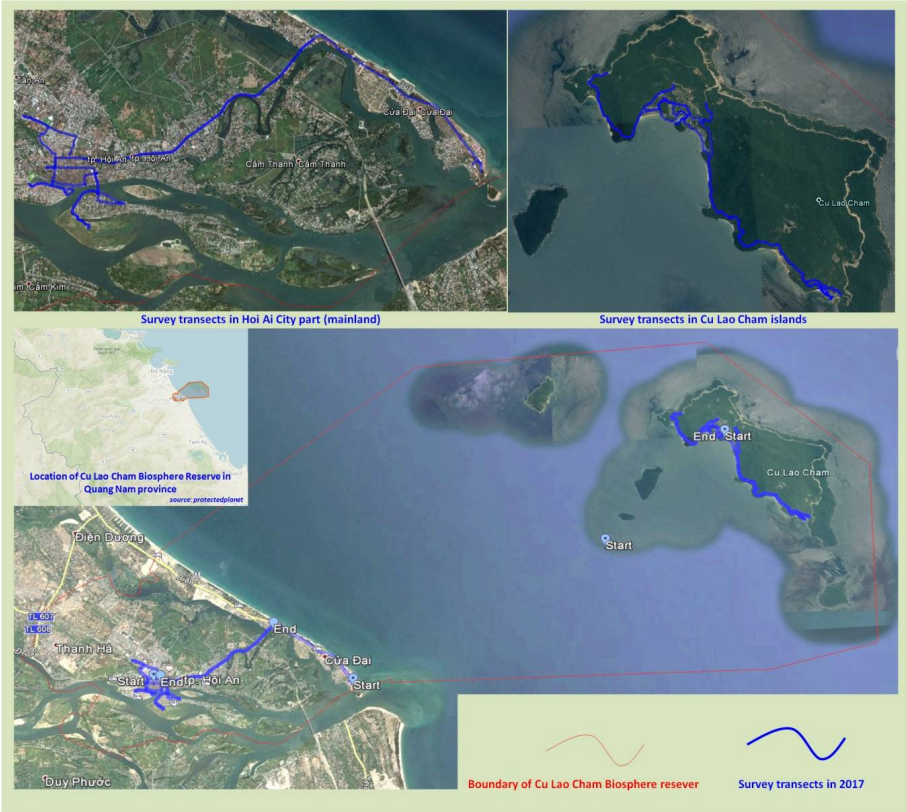

Figure 1. Alliance survey transects at Cu Lao Cham Biosphere Reserve

A field survey was planned based on the main ecological habitats of the site. Then, some transects as trails and roads were selected through almost habitats to allow assessing any site as a potential habitat of invasive species from the trail or road. In this study, four

transects were selected for the survey, two of them locates at the mainland and two others at the islands (figure 1). In the survey, the appearance of any alien was recorded by camera and GPS, most of them were collected for sample specimens. During the survey, the situation of each alliance species was recorded in a form for each survey site. The specimens then were temporary kept as study samples with suitable methods based on each objective of organism. The plant specimens were pressed and dried inside of carbon sheets. The animal specimen has not been collected but recorded as some photographs taken during the survey. The field survey activities were implemented on 5th-14th May, 2017.

Assessment of invasive situation is determined according to the criteria stimulated in Circular No. 27 and the guidelines of the GISD, ISC, focusing on: appearance as natural population, population size, risk as impacted levels to the native organism communities (low, medium or high). According to the GISD, "*alien species*" is a species, subspecies, or lower taxon (non-native, non-indigenous, foreign, exotic) occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any parts, gametes or propagule of such species that might survive and subsequently reproduce, while "*alien invasive species*" means an alien species which becomes established in natural or semi-natural ecosystems or habitat, and is an agent of change, and threatens native biological diversity. Based on that definition, we have ranked the impact level as: No risk: appearance in a controllance by the human; Low risk: random appearance of population of invasive species; Medium Risk: population of invasive species is expanding, threatening to the other species in the habitat; and High Risk: population of invasive species is threatening to the threatened/valued organism species (including the species listed in the Vietnam Red Data Book and in the IUCN Red List of Threatened Species, or endemic species of the local survey sites) and the local native habitat.

RESULTS AND DISCUSSION

List of invasive organisms in Cu Lao Cham Biosphere Reserve

In the field survey, through four transects crossing two main areas of the CLC biosphere reserve, 22 alien species including 19 plants species and 3 animal species were recorded. All of the alien plant species are flowering division (10 families) of 9 orders and 2 classes, while 3 animal alien species are belonged to 3 families in 2 divisions as mollusks (gastropods class) and vertebrates (fish class). All of those species were recorded in the mainland part of the CLC in Hoi An City, while 19 alien plant species only were appeared in the islands part of the CLC. Thus, invasive animals were found only in Hoi An Town, but not in CLC islands (table 1).

Among 22 alien species in CLC, 19 species were recorded as impacted species to Vietnam according to the GISD, 5 species was listed in the Circular No.27 and blue porter weed (*Stachytarpheta jamaicensis*) was introduced as alien species to Vietnam (CABI, 2017).

According to the Circular No.27, there were 7 alien plant species living in the CLC, including 5 exotic alien species. As a matter of fact, one species as basket plant (*Callisia fragrans*) was not recorded as an exotic invasive species in the CLC because it was planted as ornamental only both in the mainland and in the islands and 2 other species are potential exotic invasive species in Vietnam. The basket plant species has been miss-understood as a medicine plant, and local people often plant them in the gardens or keep as bonsai, that is a reason for appearance of this species there.

Among the alien species appeared in the CLC, one fish species, tilapiine cichlid fish (*Oreochromis mossambicus*), and 1 snail species, channeled apple snail (*Pomacea canaliculata*), are living in the aquatic environment, where is one aquatic plant species, water hyacinth (*Eichhornia crassipes*), is living in the aquatic habitat. All other plant species are herb or small shrub life-forms, and most of them are fast growing, short life-cycle but high potential to be induceable by seed or cutter stem.

The alien richness families are the beans (Fabaceae) with 5 alien species and the aster (Asteraceae) with 4 alien species. Those 2 alien richness families are also most richness plant families in Vietnam that is easy to meet in the most habitats including forest, scrub, grasslands, gardens, from the tropical to the subtropical zone and from the lowland to the mountain. Those families contain high potential invasiveness species in many ways, such as by human activities, animal habits, water flow, infrastructure materials, etc.

Assessment of alien species in Cu Lao Cham

The alien species including invasive species are assessed below through alphabet list of their order scientific name with plants in section A and animals in section B.

Billy goat-weed (Ageratum conyzoides)

This species is native of Tropical America but is an invasive weed in many other regions. In Vietnam, even it was listed in the Circular No.27 as a potential invasive species (MONRE & MARD, 2013).

The fruit of this species is an achene with an aristate pappus and is easily dispersed by wind. Seeds are positively photoblastic, and viability is often lost within 12 months. The optimum germination temperature ranges from 20 to 25°C. Because of annual plant, they reproduce early and having the potential for very high intrinsic rate of increase, and they can survive adverse condition as dormant seeds in the soil. People can use this plant as medicine in many countries in the world, especially in the tropical and subtropical regions. It would be used as natural biocide or herbicide (ISSG, 2015).

This species was introduced to Vietnam as an alien species in 1979 (CABI, 2017).

In the CLC, this species widely appears and its population creates in the nature, from the gardens, crop fields to the roadsides and other scrubs close to the forest of the islands. The population was formed on uncultivated lands after strong interference of human activities in the past, including forest cutting, road construction, gardening, etc. The population size is about several m^2 and not impacted to the native habitat as forest or scrubs of the islands (no strongly growing individual was found under canopy of the forest or inside of the native coastal scrub). In this assessment, this species was ranked as Low Risk.

Beggar-ticks (Bidens pilosa)

This herb, originated from the Americas, typically bears 80 flower heads with seeds with potential production of 3,000 plants in a generation and 4 generations per year. The species has been used as a medicinal plant in Africa, Asia, and tropical America. This species is a hardy weed capable of invading a vast range of habitats ranging from moist soil, sand, lime rock, or dry and infertile soil and from low to high altitudes (ISSG, 2015).

This species is native of North & South America but it has been introduced to many new locations by man for agricultural or ornamental purposes (ISSG, 2015). In Vietnam, it was first record as an alien species in 1993 (CABI, 2017). Although this species appears widely in the country, it has not been listed in the Circular No.27 (MONRE & MARD, 2013).

At Cu Lao Cham, it is very common on the roadsides and in the scrubs. On the island, it is easy to find this species at residential area, roadsides and at the scrubs and grasslands. The population of this species was created in the nature and the population size is about several m^2 and not impacted to the native habitat as the native forest (no strongly growing individual was found under canopy of the native forest even it is mixed growing in some native coastal scrubs). The population was formed after strong disturbance of the human activities in the past, including forest cutting, road construction, infrastructure construction and gardening support for the tourism, etc. Because of its wide appearance, this species is ranked as Low Risk.

Siam weed (Chromolaena odorata)

This species is native to the North and Middle America and Atlantic islands. The species is recorded in the list of 100 of the World's Worst Invasive Alien Species (ISSG, 2015), and is a very common invader in Vietnam, mostly in the secondary habitats including forest, scrubs and grassland,

appearing as natural or artificial vegetation types. The species was introduced as an alien species in Vietnam since 1992 (CABI, 2017).

The seeds of this plant are achenes and are somewhat hairy. They are mostly spread by the wind, but can also cling to fur, clothes and machinery, enabling long distance dispersal. Seed production is about 80,000 to 90,000 per plant. Seeds need light to germinate. The plant can reproduce by both of its roots and seeds. In favorable conditions the plant can grow more than 3 cm per day (ISSG, 2015).

The Siam weed was recorded as a medicinal plant in Vietnam, having been used in local communities to prevent bleeding, anti-bacteria, etc. This species has also been used as green-manure or herbicide (ISSG, 2015).

In the CLC, the Siam weed is found mostly in the islands, where it grows on uncultivated lands such as roadsides, opened forest, scrubs or grasslands. Their population in the nature strongly holds on the habitat, expanding to the surrounds even at the roadsides closed to the forest, scrubs and grassland in the core area of the CLC biosphere reserve. The population is formed on the uncultivated lands after strong disturbance of the human activities in the past, including forest cutting, road constructing, infrastructure constructing and gardening support for the tourism, etc., or after natural landslide in some places of the islands. The size of its population is diverse, from several to hundreds m^2, and it makes a Medium Risk to the habitat of the local species and landscape of the islands.

Vilfa stellata (Cynodon dactylon)

This species, also known as bermuda grass, is originated from the Middle East and has not been listed in the Circular No.27. However, it is common on the wetlands, moisture uncultivated lands in Vietnam.

The plant can reproduce by both of its roots and seeds.

This herb has been used for environmental purposes to prevent soil erosion, animal food and sometimes as medicines (ISSG, 2015).

The vilfa stellata was introduced as an alien species in Vietnam since 1979 (CABI, 2017).

In the CLC, this invader has been appearing at almost moist and uncultivated lands include gardens, crop fields and infrastructure constructing land. The population size is in several m^2, but it seems to be not strongly expandable because of limited growth by moisture. Thus, the appearance of this species in the CLC is ranked as Low Risk.

Coast morning glory (Ipomoea cairica)

The origin of this species is uncertain but is believed to be Africa or Arabia origin. Due to human dispersal, it occurs today on most continents as an introduced species and is sometimes a noxious weed. It is a major problem along the coast of many places of the world (ISSG, 2015). In Vietnam, it appears in many coastal palaces but this species has not yet been listed in the Circular No.27 (MONRE & MARD, 2013).

Somewhere, this species is used for ornamental because of its beautiful flowers.

It can grow as a separate plant if snapped during attempted removal process. In the nature, when this species creates their population, it typically covers on over the canopy of many trees and shrubs, leading death of native species and becomes a successful invader.

This species has not been recorded as an alien in Vietnam. In this study, we have introduced this species as an invasive plant for Vietnam national alien invasive list.

In the CLC, this species is common in both of mainland and islands, mostly at coastal places, sometimes is in gardens, uncultivated lands such as infrastructure constructing area and roadsides. Their population in the nature is in several to hundreds m^2 and make a Medium Risk for the native habitat in the islands.

Wild-sage (Lantana camara)

This species is native to the American tropics, often planted to embellish gardens and now, this has spread to around 50 different countries where it has become an invasive species. This is listed in the 100 of the World's Worst Invasive Alien Species (ISSG, 2015) and is listed in the Circular No.27 (MONRE & MARD, 2013).

Their seeds germinate very easily. It can cause problems if it invades agricultural areas because of its toxicity to livestock as well as its ability to form dense thickets which, if left unchecked, can greatly reduce the productivity of farm land (ISSG, 2015).

The Wild-sage has several uses, mainly as an herbal medicine and in some areas as firewood and mulch. In some countries, it is planted as a hedge to contain or keep out livestock. The extract from their leaves exhibits antimicrobial, fungicidal, insecticidal and nematicidal activity. The use of lantana extracts as potential biocides has been suggested. Its application as a weedicide would depend on the size of the water-bodies being treated and the cost of extraction of the leachate. The stems of lantana, if treated by the sulphate process, can be used to produce pulp for paper suitable for writing and printing, although it is hard to harvest, and is likely to be uneconomical. The roots of lantana contain a substance that may possibly be used for rubber manufacture, although the economic viability of production has not been examined. Lantana twigs and stems serve as useful fuel for cooking and heating in many developing countries although it is less important than other fuel sources such as windrows, woodlots or natural bush (ISSG, 2015).

In Vietnam, this species is planted commonly, so that, it has been induced for many places, especially on dried and sandy areas such as coast scrubs, gardens and plantation forest, etc. The species was introduced in Vietnam as alien since 1979 (CABI, 2017).

In the CLC, the Wild-sage appears in many places, including gardens, uncultivated land, coastal scrubs and roadsides even the road through the core area of the biosphere reserve. Thus, this invader is impacting to the native habitats including secondary forest and scrub, grassland of the islands. In this survey, this species is ranked as Medium Risk.

Sleepy plant (Mimosa pudica)

The species is native to the South and Central America, but is now a pan-tropical weed. It grows mostly in undisturbed shady areas, under trees or shrubs. In invading areas, this species forms a dense ground cover, preventing reproduction of other species. It has become a serious weed in crop fields in many tropical areas. On the other hand, this can change the physico-chemical properties of the soil where it invades. For example, the total nitrogen and sodium has been increased significantly in invaded areas (ISSG, 2015). In Vietnam, it has not been listed in the Circular No.27 (MONRE & MARD, 2013).

The seeds and other plant parts of the sleepy plant contain mimosine, and, in scientific trials, the extracts of the plant have a moderate diuretic activity, and to depress duodenal contractions similar to atropine sulphone, to promote regeneration of nerves, and to reduce menorrhagia. Their root's extracts are reported to be a strong emetic. This has been used as a part of traditional medicine in Southeast and South Asia and sometimes, it is also a popular ornamental plant (ISSG, 2015).

Because of flowers all year round, and may produce as many as nearly 700 seeds per plant per year. The seed is easily carried out by the wind, so that it is easy to induce to the new area. In Vietnam, this species was introduced as an alien species since 1977 (CABI, 2017) and now it is common weed but it has not strong impact to the native habitat. In the CLC, situation is same as other places of Vietnam. The sleepy plant is found in many places in the CLC, but it has not clear impact to the native habitat with its population size of several or less m^2. The appearance of this species in the CLC is ranked as Low Risk.

Rose myrtle (Rhodomyrtus tomentosa)

According to the GISD (ISSG, 2015), this species is large evergreen shrub native to Southeast Asia that has become an invasive species in other tropical and subtropical countries, was introduced to many areas as an ornamental plant, it has spread, forming large, monospecific thickets that displace native flora and fauna. Areas especially affected include Florida, Hawaii and French Polynesia. It grows in coasts, natural forest, riparian zones,

wetlands, moist and wet forests, bog margins, from sea level up to 2,400 m elevation. Thus, it has the potential to alter the natural fire regimes of invaded areas. This plant can grow in a wide range of soil types, including salty coastal soil, but is sensitive to heavy salt spray. Especially, this species is able to resprout prolifically after fire. This species has been introduced as an impacting species to Vietnam (ISSG, 2015) but it has been not listed in the Circular No.27.

This species would be used as an ornamental. Its fruit is edible and trading in Vietnam.

Their seeds are dispersed by frugivorous birds, can only spread by seed drop, as it does not spread vegetative, it has a large amount of seed production and high germination rate, usually contain 40-45 seeds (ISSG, 2015).

In the CLC, Rose myrtle is common in the scrubs, at the roadsides or understorey of plantation forest. The population size is in several to hundreds m^2. It has not been listed in the Circular No.27, and within CLC as a particular situation, the appearance of this species is ranked as Low Risk.

Guava (Psidium guajava)

The guava has flowers and fruits year-round; seeds can remain viable for months, and has been reported for up to a year; usual germination time is 2 to 3 weeks, but they can take up to 8 weeks. Trees grown from seed produce fruit in 2 to 4 years, with a life expectancy of 30 to 40 years, grows in both humid and dry climates; lives at altitudes from 0 to 2,740 m; drought-tolerant, but prefers annual rainfall between 1,000-20,000 mm; indiscriminate as to soil type; grows well on heavy clay, marl, light sand, gravel bars or limestone ranging from pH 4.5-9.4; it is salt-tolerant to a certain degree; tolerates wet areas, but prefers locations with good drainage; trees die back if summer temperatures average less than 15°C, and they are also intolerant of intense daytime heat; survives only light frost; prefers full sun but will grow in semi-shade (ISSG, 2015).

The species is native to tropical America, probably from southern Mexico to South America, but its distribution has been greatly extended through cultivation and it is now widespread throughout the tropics and subtropics. Currently, this species is naturalized in the Old World tropics and in the West Indies. The species was presumably introduced into the West Indies by ancient human migration from northern South America. (CABI, 2017).

In Southeast Asia, Guava is an invasive plant in Singapore and the Philippines (CABI, 2017). This species has been assessed as impacting to Vietnam by GISD (ISSG, 2015) and according to the data of ISC, this species was first recorded as an alien to Vietnam in 2012 (CABI, 2017), although it has not yet been listed in the Circular No.27.

This species would be used as ornamental, medicine, and its fruit is delicious and is an common trading material in Vietnam.

P. guajava is a fast growing tropical and subtropical species adapted to a wide range of environmental conditions. It is tolerant of shade, a precocious and prolific reproducer with seed dispersal aided by avian and mammalian vectors. It can form dense thickets which displace native vegetation and is reported as an invasive weed in many countries. The balance between its valuable fruit production and its invasive potential requires careful monitoring (CABI, 2017).

In the CLC, the guava is common in the scrubs, especially at the local burial grounds and close to the forest. The population size is in hundreds m^2. The quality of fruits there is not ranked as a trading class. The local people call it "*forest guava*". It has not been listed in the Circular No.27, and within CLC as a particular situation, the appearance of this species is ranked as Low Risk.

Bay Biscayne creeping-oxeye (Sphagneticola trilobata)

According to the CABI (2015), this species is native to Mexico, Belize, Costa Rica, Guatemala, Nicaragua, Panama, Saint Lucia (Central America) and South America, it is widely cultivated as an ornamental groundcover, grows well in open areas up to

700 m or more in elevation although it is commonly a coastal species. According to the GISD (ISSG, 2015), this species has a very wide ecological tolerance range, and seems to be requally suited to dry and moist sites, although it seems to prefer and do best in sunny sites, it survives very well in shady sites, it grows well on almost all soil types, including bare limestone and nutrient poor sandy beaches and swampy or waterlogged soils. It is tolerant to inundation and high levels of salinity. This is listed in the 100 of the World's Worst Invasive Alien Species (ISSG, 2015), and also listed in the Circular No.27 (MONRE & MARD, 2013).

It is spread by people as an ornamental or groundcover that is planted in gardens, and then it is spread into surrounding areas by dumping of garden waste. It spreads vegetative, not by seed. It rapidly forms a dense ground cover, crowding away and preventing other plant species from regenerating. This species is widely available as an ornamental and is therefore likely to spread further. It is a noxious weed in agricultural land, along roadsides urban waste places and other disturbed sites. It is also invasive along streams, canals, along the borders of mangrove swamps and in coastal vegetation (ISSG, 2015).

Dang Van Son & Tran Hop (2011) recorded this species as an invasive plant impacted at Binh Chanh District, Ho Chi Minh City. We have not found any another announcement of this species' invasiveness.

In the CLC, both in mainland and islands, this species is common in the gardens, uncultivated lands, infrastructure constructing lands, roadsides including the coastal roads and the roads at residential or core areas. At the garden scale, it often covered several to hundred m^2 but in the nature, the population size is limited to only several m^2. Because of its spreading capacity, the population size in the nature is limited, and the appearance of this species in the island is ranked as Low-Medium.

Blue porterweed (Stachytarpheta jamaicensis)

According to the ISC, blue porterweed is generally agreed to be native to tropical America but were already known in Asia in the 18th Century. The species is now widespread in Central America, the Caribbean, East and South Asia and the Pacific, but scarcely occurs in Africa. This species thrives in moist, fertile soils, but will also tolerate seasonal drought. It tolerates soil compaction, vehicular passage and trampling by livestock, and grows in a wide range of soils. It requires medium to high light intensities and grows poorly in dense shade. In addition to the listed crops, *S. jamaicensis* is also a major weed in pastures throughout the tropics, and a minor weed in many other tropical vegetable and plantation crops. It is also common in uncultivated sites such as pastures, roadsides, gardens, parks, fence lines and around habitation and farm buildings (CABI, 2017).

This species is a perennial woody herb, which reproduces solely by seed. Mature seeds remain within the dry, brittle fruiting spike. Up to 2,000 seeds have been recorded per plant. The seeds have no obvious method of dispersal other than in contaminated trash and soil. They may also pass unharmed through the digestive system of herbivores. Seeds remained viable for 6.5 years when buried 15 cm deep in soil in the Philippines. The plant grows in a wide range of environments but prefers moist, uncultivated soils. Following damage resulting from trampling, grazing and mowing it is able to regrow from dormant buds at and below soil level. Plants are destroyed by cultivation, which if frequent enough to prevent the production of viable seed, will result in eradication of the weed. This species is usually a minor weed of cultivation due to frequent soil disturbance but may become serious in unimproved pastures, especially where these are regularly overgrazed. It is also common in wasteland and other disturbed but unused areas (CABI, 2017).

This species was first record as an alien plant in Vietnam since 1991 (CABI, 2017) but the species has not been listed in the Circular No.27.

In the CLC, this specie is common on roadsides, gardens, and infrastructure constructing areas. Especially, this is common at the roadsides within the core areas of the island, very closed to the forest and other native

scrubs. Their population size in the nature is several m^2. Base on the field survey, the appearance of this species in the island is ranked as Low Risk.

Giant sensitive tree (Mimosa pigra)

This species is a woody invasive shrub that originates from tropical America and has now become widespread throughout the tropics. This has been listed as one of the world's 100 of the World's Worst Invasive Alien Species. This plant forms dense, thorny, impenetrable thickets, particularly in wet areas. In sandy soils, the lifespan of their seeds may be much longer. Dormancy of seeds in the soil is broken by expansion and contraction of the hard seed-coat by temperature changes ranging from about 25-70°C. Seeds buried deeper than 10 cm generally do not successfully germinate unless brought to the surface. The Giant sensitive tree favors a wet-dry tropical climate and grows in open, moist sites such as floodplains, coastal plains and river banks. In both Australia and Vietnam it prefers to invade seasonally inundated grassland. This is due to the ability of their seeds to establish rapidly on bare soils, which lack competitive pressures imposed by other seedlings. Seeds are produced in individual segments of seed-pods that 'burst' apart when mature. Under optimal conditions, their annual seed production may reach up to 220,000 per plant. On the way to be invader, this species would be introduced to the new areas by seeds or seed samples, it was introduced and planted to reduce erosion or as an ornamental plant and sometimes, their seeds may adhere to vehicles or other machinery (ISSG, 2015).

The Giant sensitive tree was first reported as an alien invasive plant to Vietnam in 1990 (CABI, 2017). In the country, it is typically found along the edge of both natural and manmade water bodies and along roadsides. This plant does not appear to grow preferentially in any soil type, but is found most commonly in soils ranging from black cracking clays to sandy clays to coarse siliceous river sand. Seed production and plant life expectancy are greater on black cracking clays than on the lighter clays and silty loams. In the Mekong Delta, it was found that the average number of seeds in the topsoil was 100 seeds per meter squared (ISSG, 2015). This species has already been listed in the Circular No.27 (MONRE & MARD, 2013).

In the terrestrial part of the CLC, it was found on wet, moisture lands such as uncultivated lands, infrastructure constructing area, especially on the banks of Bon River, islands in the estuarine area of Bon River. In the islands, this species is found commonly at moisture uncultivated land and on the roadsides even the road through the core area. Their population at moisture area is several m^2 but at the roadsides, it was scattered. Because of limited moisture around their population, even this species is high risk for the local native habitat and organisms at some places in Vietnam, but within the CLC, at the moment, it has limited expansion because of moisture, soil types on the island. Thus, the appearance of this species at the CLC is ranked as Medium Risk.

Water hyacinth (Eichhornia crassipes)

This is an aquatic plant native to the Amazon basin, and is often a highly problematic invasive species outside of its native range. In many areas it has become an important and pernicious invasive species. Its habitat ranges from tropical desert to subtropical or warm temperate desert to rainforest zones. The water hyacinth reproduces both vegetative and sexual ways. However, the vegetative reproduction is more important. Its flowers year-round and its fruit is a thin-walled capsule enclosed in a relatively thick-walled hypanthia developed from the perianth tube. Mature seeds can number 450 per capsule. Water hyacinth grows and spreads rapidly under favorable temperature and nutrient conditions. Stolon buds develop that bear offshoots from auxiliary buds and stolons are readily distributed by water currents, winds and boat traffic (ISSG, 2015).

This species is listed in the world's 100 of the World's Worst Invasive Alien Species (ISSG, 2015), and also is listed in the Circular No.27 (MONRE & MARD, 2013). According

to the data of ISC, the species was first recorded as an invasive plant in Vietnam in 1987 (CABI, 2017). In Vietnam, it is very common on the fresh aquatic habitats, from the ponds to the rivers. Even it makes a lot of problems for traffic on the river, pollution for the aquatic environment, strong competition habitat with the native species, etc. This species is also useful in some case such as for hand made production, food for animal, etc. Because of its extremely high rate of development, this species is an excellent source of biomass. Besides, the roots of water hyacinth naturally absorb pollutants, including lead, mercury, and strontium-90, as well as some potentially carcinogenic organic compounds, in concentrations 10,000 times that in the surrounding water. The water hyacinths can be cultivated for waste water treatment. It is also an edible plant as a carotene-rich table vegetable in Taiwan while the Javanese sometimes cook and eat the green parts and inflorescence (ISSG, 2015).

In the CLC, water hyacinth lives in some aquatic areas (fresh water) such as ponds, river, but mostly found at Thu Bon estuarine area and some small ponds/streams in the islands. The population size is limited in several m^2, it is limited by the salty of the water within estuarine area and also limited by the limited appearance of ponds and streams on the islands. Thus, even it was recorded in the world list of invasive specie of the world, within boundary of the CLC, it was ranked at Low Risk.

Other alien species

The other alien species appeared in the CLC but have not been invasive species include 6 plants and 3 animal species. As the alien plant species, while the black wattle (*Acacia mangium*) has been planted but controlled within the plantation forest scale only. Basket plant (*Callisia fragrans*) and creeping wood sorrel (*Oxalis corniculata*) are planting as ornamental but there is no nature population found in the biosphere reserve. White lead tree (*Leucaena leucocephala*) is planted as nature fencing in the garden scale. Wild maracuja (*Passiflora foetida*) exists very rare in the nature as separated individuals. Torpedo grass (*Panicum repens*) appears limited in some aquatic (fresh water) area in the islands (it is very small areas) and limited by the salty sand in the Hoi An area. As for the animal alien species, both of them are living in the aquatic habitat (fresh water) in the Hoi An part of the biosphere reserve. Within the estuarine area of Bon River, they are limited because of the salinity. Channeled apple snail (*Pomacea canaliculata*) exists but it has not been recorded as an impact for the local habitat. Giant African snail (*Achatina fulica*) lives in the gardens but limited by the sandy soil. It has not been recorded as an impact for the local habitat too. The fish alien species, tilapiine cichlid fish (*Oreochromis mossambicus*), lives in the aquatic habitat of fresh water, because of the limitation of fresh water environment of the CLC, this fish has been recorded as non-invasive.

CONCLUSION AND RECOMMENDATION

Among 19 alien plant species existing in the CLC, 13 are invasive species that include 3 medium risk species, siam weed (*Chromolaena odorata*), coast morning glory (*Ipomoea cairica*) and wild-sage (*Lantana camara*), and 10 are low risk ones. All of the medium risk invasive species appear on the islands. Siam weed (*Chromolaena odorata*) is not recorded impacting in the mainland the CLC biosphere reserve. All of the animal alien species were recorded appeared in the biosphere reserve, but not in the islands and are recorded as non-invasive species.

In general, the impact of alien species within the CLC is assessed as Low Risk and the impact at the Hoi An part is more serious than the islands because most of the habitats in Hoi An were formed as the passive results caused by human activities such as construction, gardening, crop cultivation etc., whereas on the islands, the forest is the only main habitat of the core area.

Even the impact of the alien species in the CLC is at low risk, it is necessary to still conduct some solution to control them as soon as possible because of the increase of tourism

and the construction activities to support tourism development are undergoing in many places of the islands, especially on the roads at the core area.

Based on the results of this study, we also suggest that, seven species, beggar-ticks (*Bidens pilosa*), coast morning glory (*Ipomoea cairica*) bay biscayne creeping-oxeye (*Sphagneticola trilobata*), blue porterweed (*Stachytarpheta jamaicensis*), vilfa stellata (*Cynodon dactylon*) guava (*Psidium guava*) and rose myrtle (*Rhodomyrtus tomentosa*) should be added in the national alien species list that sould be replaced for the current list in the Circular No.27. About 4 species, beggar-ticks (*Bidens pilosa*), coast morning glory (*Ipomoea cairica*), bay biscayne creeping-oxeye (*Sphagneticola trilobata*) and blue porter weed (*Stachytarpheta jamaicensis*), together with billygoat-weed (*Ageratum conyzoides*) would be listed in the invasive appendix of Vietnam nation invasive species list (the list based on the current criteria of the Circular No.27) while two other species as vilfa stellata (*Cynodon dactylon*) and Rose myrtle (*Rhodomyrtus tomentosa*) should be listed in the potential invasive appendix of that list.

Acknowledgements: This study is donated by the project "Study on scientific foundation to equal relationship between biodiversity conservation and sustainable live hood social - economic development at Cu Lao Chao biosphere reserve, Hoi An" hosted by the Institute of Geography (VAST) in 2016-2019 (code ĐTĐL.XH-02/16). We would like to thank the project leader, project local member for their support for us during the field survey activities.

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Table 1. List of alien species appearing in the Cu Lao Cham Biosphere Resever

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	IC	HA
A. Plants: Magnoliophyta									
A1. Magnoliopsida									
Asterales: Asteraceae (1)									
1.	*Ageratum conyzoides* L., 1753 * Synonym: *A. album* Hort.Berol. ex Hornem.; *A. ciliare* Lour.; *Cacalia mentrasto* Vell.; *A. obtusifolium* Lam.; *Cacalia mentrasto* Vell.; *Eupatorium conyzoides* (L.) E.H.L.Krause	Cỏ cứt lợn	Billy goat-weed	Colombia Costa Rica Ecuador Nicaragua Peru Solomon islands	America, Asia, Australia, Europe	1979	Scrubs, roadsides, gardens	✓	✓
2.	*Bidens pilosa* L., 1753 Synonym: *B. leucantha* (L.) Willd.; *B. leucantha* Willd. var. *sundaica* (Blume) Hassk.; *B. sundaica* Blume; *Coreopsis leucantha* L.; *B. odorata*	Đơn buốt	Beggar-ticks	America	Global	1993	Scrubs, roadsides, gardens	✓	✓
3.	*Chromolaena odorata* (L.) R.M.King & H.Rob., 1970* Synonym: *Eupatorium odoratum* L.; *Osmia odorata* (L.) Sch.Bip.; *C. odorata* (L.) R. King & H. Robins.	Cỏ lào	Siam weed	America	Global	1997	Scrubs, roadsides	✓✓	+
4.	*Sphagneticola trilobata* (L.) Pruski, 1996 Synonym: *Complaya trilobata* (L.) Strother; *Silphium trilobatum* L.; *Thelechitonia trilobata* (L.) H.Rob. & Cuatrec.; *Wedelia carnosa* Rich.; *W. paludosa* DC.; *W. trilobata* (L.) Hitchc.	Cỏ xuyến chi, Sài ba thùy	Bay Biscayne creeping-oxeye	Mexico, C.America, Caribbean	Oceania, Pacific islands	2011	Scrubs, roadsides, gardens	✓	✓
Fabales: Fabaceae (2)									

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	IC	HA
5.	*Acacia mangium* Willd., 1806 Synonym: *A. glaucescens* Kaneh. & Hatus.; *Mangium montanum* Rumph.; *Racosperma mangium* (Willd.) Pedley	Keo tai tượng	Black wattle	Queensland, PNG		Planted	Plantation forest	+	+
6.	*Leucaena leucocephala* (Lam.) de Wit, 1763* Synonym: *Acacia frondosa* Willd.; *A. glauca* (L.) Willd.; *A. leucocephala* (Lam.) Link; *A. leucophala* Link; *L. glabra* Benth.; *L. glauca* Benth.; *Mimosa glauca* sensu L.; *M. glauca* Koenig ex Roxb.; *M. leucocephala* Lam.; *M. leucophala* Lam.	Keo dậu	White lead tree	Mexico, Belize	America and other Tropics	2007	Gardens	+	+
7.	*Mimosa pigra* L., *1759**	Mai dương, Trinh nữ gỗ	Giant sensitive tree	C.&S. America	Tropics	1990	Scrubs, roadsides, gardens	✓	✓
8.	*Mimosa pudica* L.,1753	Trinh nữ	Sleepy plant	C.&S. America	America and other Tropics	1977	Roadside	✓	✓
Lamiales: Verbenaceae (3)									
9.	*Lantana camera* L., 1753 * Synonym: *L. antillana* Raf., *L. asperata* Vis., *L. spinosa* L. ex Le Cointe, *L. crocea* Jacq., *L. glandulosissima* Hayek, *L. mexicana* Turner, *L. mixta* Medik., *L. moritziana* Otto & A.Dietr., *L. sanguinea* Medik., *L. spinosa* L. ex Le Cointe, *L. undulata* Raf., *L. urticifolia* Mill.	Bông ổi, Ngũ sắc	Wild-sage	C.&S. America	America and other Tropics	1979	Scrubs, roadsides, gardens	✓✓	✓✓

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	IC	HA
10.	*Stachytarpheta jamaicensis* (L.) Vahl, 1804[(¥)] Synonym: *Verbena jamaicensis* L., *Abena jamaicensis* (L.) Hitchc., *S. bogoriensis* Zoll. & Moritzi, *S. pilosiuscula* Kunth,*Valerianoides jamaicense* (L.) Kuntze, *Verbena americana* Mill., *V. pilosiuscula* (Kunth) Endl., *Zappania jamaicensis* (L.) Lam.	Đuôi chuột	Blue porter weed	Caribbean	Tropics	1991	Scrubs, roadsides	✓	✓
Malpighiales: Passifloraceae (4)									
11.	*Passiflora foetida* L., 1753	Lạc tiên	Wild maracuja	America	Global	1991	Scrubs, roadsides	+	+
Myrtales: Myrtaceae (5)									
12.	*Psidium guajava* L., 1753 Synonym: *P. guajava var. cujavillum* (Burm.f.) Krug & Urb. *P. guajava var. guajava; P. guajava var. minor* Mattos	Ổi	Guava	C.&S. America	Global (tropical & sub-tropical)	2002	Scrubs, roadsides	✓	+
13.	*Rhodomyrtus tomentosa* (Aiton) Hassk., 1842 Synonym: *Cynomyrtus tomentosa* (Aiton) Scriv.; *Myrtus canescens* Lour.; *Myrtus tomentosa* Aiton; *R. tomentosa var. tomentosa*	Sim	Rose myrtle	Himalayas, Malaysia, Philippines	S.E Asia, E.US, Australia	2012	Scrubs, roadsides	✓	+
Oxalidales: Oxalidaceae (6)									
14.	*Oxalis corniculata* L., 1753	Chua me hoa vàng	Creeping wood sorrel	Oceania, Pacific America	Global	1977	Ornamental	+	+
Solanales: Convovulaceae (7)									
15.	*Ipomoea cairica* (L.) Sweet, 1827* Synonym: *Ipomoea palmata* Forssk.; *Ipomoea stipulacea* Jacq.	Bìm cảnh	Coast morning glory	Uncertain	Africa, New South Wale, S.E. Asia, US	None	Coastal srubs, gardens, roadsides	✓✓	✓✓

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	IC	HA
A2. Liliopsida									
Commelinales: Commelinaceae (8)									
16.	*Callisia fragrans* (Lindl.) Woodson, 1942 *(¥) Synonym: *Rectanthera fragrans* (Lindl.) O.Deg.; *Spironema fragrans* Lindl.; *S. orthandrum* Lindb.;	Cây lược vàng	Basket plant	Mexico	S.E Asia, C.Ameria, Caribbean, Oceania	2013	Ornamental	+	+
Commelinales: Ponteridaceae (9)									
17.	*Eichhornia crassipes* (Mart.) Solms, 1883 * Synonym: *Eichhornia cordifolia* Gand.; *E. crassicaulis* Schltdl.; *E. crassicaulis* Schltr.; *E. speciosa* Kunth; *Heteranthera formosa* Miq.; *Piaropus crassipes* (Mart.) Raf.; *P. mesomelas* Raf.; *Pontederia crassicaulis* Schltdl; *P. crassicaulis* Schltr.; *P. crassipes* Mart.; *P. crassipes* Roem. & Schult.; *P. elongata* Balf.	Bèo lục bình	Water hyacinth	Amazon	Global	1987	Ponds (fresh water)	✓	✓
Cyperales: Poaceae (10)									
18.	*Cynodon dactylon* (L.) Pers., 1805 Synonym: *Capriola dactylon*, (L.) Kuntze; *Cynodon coursii* A. Camus; *C. polevansii* Stent; *Digitaria stolonifera* Schrad.; *Panicum dactylon* L.	Cỏ gà	Vilfa stellata	Middle East	America, Oceania, Pacific islands, S.E. Asia	1979	Scrubs, roadsides	✓	✓
19.	*Panicum repens* L. 1762 Sysnonym: *P. airoides* R. Br.; *P. aquaticum* A. Rich.; *P. arenarium* Brotero; *P. ischaemoides* Retz.	Cỏ cựa gà, Cỏ ống	Torpedograss	Eurasia	Global	1979	Scrubs, roadsides, gardens	+	+
B. Animals									
B1. Molluca: *Gastropoda*									
Ampullariidae (11)									

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	IC	HA
20.	*Pomacea canaliculata* Lamarck, 1819	Ốc bươu vàng	Channeled apple snail	S.American	Global	1988	Pond, river	+	+
Achatinidae (12)									
21.	*Achatina fulica* Férussac, 1821 Synonym: *A. fulica* Férussac, 1821; *Helix fulica* Férussac	Ốc sên	Giant African snail	E.Africa	Global	1937	Gardens	+	+
B2. Chordata: *Actinopterygii*: Perciformes**:** Cichlidae (13)									
22.	*Oreochromis mossambicus* W. K. H. Peters, 1852 Synonym: *Chromis mossambicus* W. K. H. Peters; *Sarotherodon mossambicus* W. K. H. Peters; *Tilapia mossambica* W. K. H. Peters; *C. dumerilii* Steindachner; *C. vorax* Pfeffer; *T. vorax* Pfeffer; *C. natalensis* M. C. W. Weber; *T. natalensis* M. C. W. Weber; *T. arnoldi* Gilchrist & W. W. Thompson; *Oreochromis mossambicus bassamkhalafi* Khalaf	Cá rô phi	Tilapiine cichlid fish	S.Africa	S. Africa, S.E. Asia, Japan, China, Taiwan,	1951	Rivers	+	+

***Note**: HA - Hoi An City; CI - Cham Islands;*
✓- Impacting as low Riks; ✓✓- Impacting as Medium Riks; + - Not impacting;
(*) - Circular No. 27; (¥) - ISC; E.-East; N.-North; S.-South; C.-Central;