Chapter 33
Aquatic Fauna and Aquaculture

Lim Puy

33.1 The Floodplain and Its Habitats

The ecosystem of Tonle Sap Lake (TSL) serves as a complex flood regulator that is fundamental for wetlands and biodiversity of the lake itself and the wider Mekong Delta. The flood-pulse-induced bi-directional flow in the TSL system seasonally inundates the lake floodplains during the rainy season, creating heterogeneous habitats and diverse ecosystems for aquatic fauna communities (Figs. 33.1 and 33.2; see Chaps. 1–4, 31, 32, and 34). This chapter describes major aquatic fauna with their habitats and present status.

The wetland around TSL including the grassland covers approximately 2520 km^2 (Legris and Blasco 1972). We conducted a study during the dry and the rainy seasons between 2018 and 2019; the results indicated that the inundated area of the seasonally flooded habitats (Fig. 33.1) varied from 1314 to 5343 km^2 when the water level at the hydrological stations varied from 2 to 5 m at the beginning of the rainy season (July–August), respectively. As the seasonally flooded habitats become inundated when the water level rises, reaching 8–9 m in October, many plant species produce fruit and seeds (Arias et al. 2013).

The junction between the lake and its outlet to Tonle Sap River (TSR), called "bottle-neck," plays a prominent role in maintaining the minimum water level in the lake necessary for the survival of the biotic communities by constituting a natural sediment trap for the inflow from Mekong River (MR, Fig. 33.2). The 11 major tributaries of TSL and their sub-basins also play a secondary role in maintaining the water level in the back swamp of TSL during the dry season (see also Chap. 8).

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C. Yoshimura et al. (eds.), *Water and Life in Tonle Sap Lake*,
https://doi.org/10.1007/978-981-16-6632-2_33

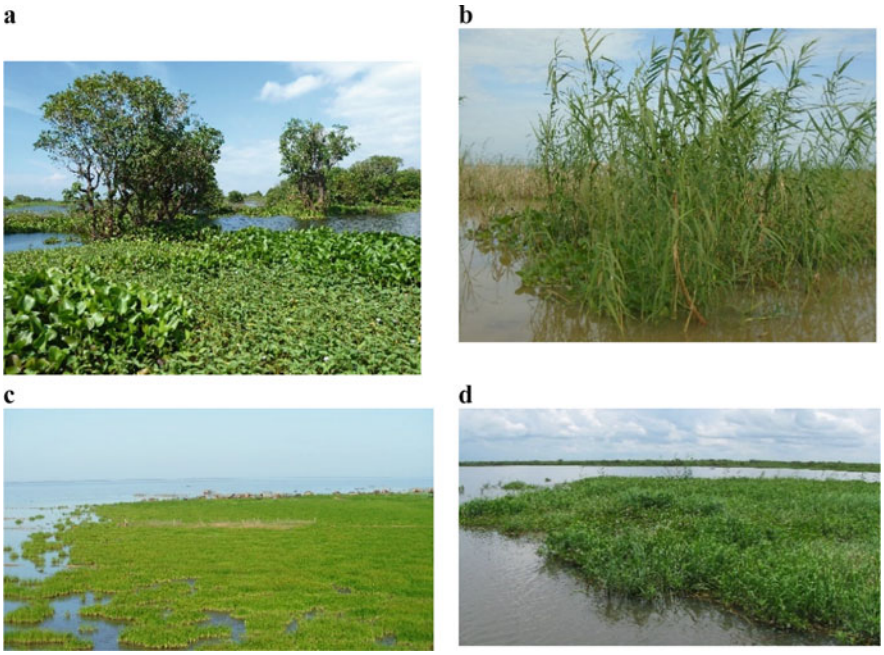

Fig. 33.1 Habitats for spawning and growth for the fish community. (**a**) *Barringtonia acutangula*, *Eichhornia crassipes.* (**b**) *Phragmites* spp. (**c**) *Cynodon dactylon.* (**d**) *Cyperus elatus*

33.2 Fish

33.2.1 Inventory of Fish Species

Fish species in the TSL system have been well reported compared to other faunas. Campbell et al. (2006) claimed 149 fish species in TSL, whereas Nam et al. (2006) highlighted around 200 fish species, encompassing 35 families and 90 genera. Based on the inventory in 2010–2019, the Tonle Sap Authority (TSA) has listed 167 species, belonging to 12 orders, 35 families, and 94 genera. Among all the identified samples, 73% belonged to several genera including Cypriniformes (genus: *Paralaubuca*, *Puntioplites*, *Labiobarbus*, and *Henicorhynchus*), Siluriformes (genus: *Mystus* and *Pangasius*), and Perciformes (genus: *Parambassis*). The inventoried 167 species were classified into four categories: high consumption (commonly caught/processed by population for food), high market value, endangered species, and introduced species (Tables 33.1 and 33.2).

The knowledge of the relationship between species and habitats is necessary for better understanding of the environmental requirements of fish fauna, which are critically important for the conservation of fish fauna diversity and productivity (Chan et al. 2020), especially in a complex hydroecological system such as TSL. During the early tropical monsoon rainfalls, many fish species in MR start to

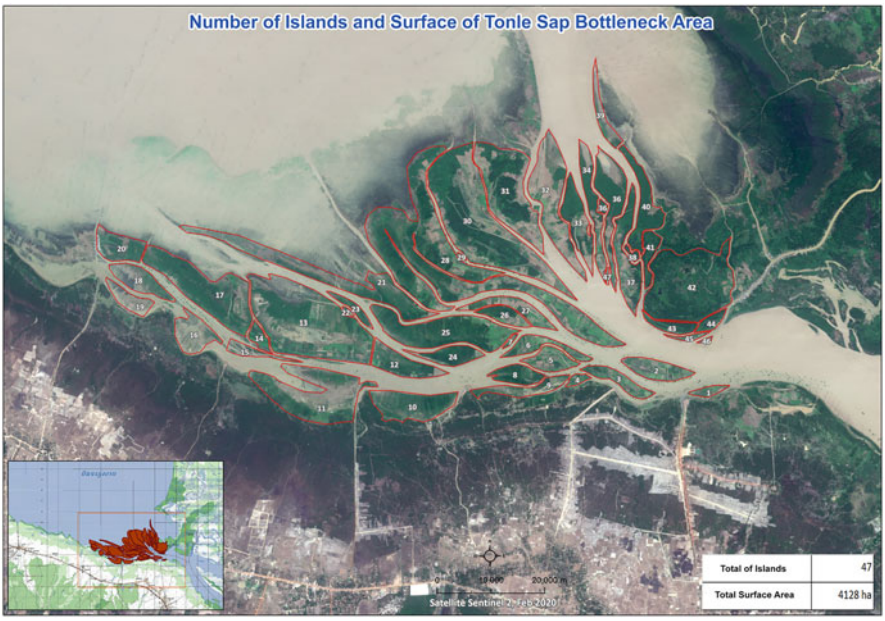

Fig. 33.2 Chhnok Trou and Tonle Sap River branches forming a complex of 47 islands at the bottle-neck junction with Tonle Sap Lake, at a water level <0.5 m

Fig. 33.3 *Catlocarpio siamensis* (local name: Trey Kol Reang, left panel) and *Probarbus jullieni* (Trey Trasark, right panel)

disperse for spawning and longitudinally migrate to the lower floodplain habitats (e.g., TSL and flooded area) for feeding and growth. These migratory fish species access the seasonally flooded habitats to feed during the wet season (Campbell et al. 2006). During the dry season, when the water level recedes, the longitudinal migratory fishes migrate from TSL back to MR to escape from the contracting condition in the floodplain and the lake, for better water quality and deeper pools as a refuge in the dry season (Poulsen et al. 2004). By surveying the dai fishery lot (bagnet fishery, mainly located along TSR; see Chap. 48) from 2011 to 2020, we observed that genera *Clupeichthys*, *Paralaubuca*, *Puntioplites*, *Thynnichthys*,

Table 33.1 Fish species classification

Fish species classification	Fish
High consumption and processing comprising 43 species belonging to 3 orders and 13 genera	*Clupeidea*, *Clupeichthys*, *Paralaubuca*, *Thynnichthys*, *Dangila*, *Henichorhynchus*, *Botia*, *Mystus*, *Pangasius*, *Parambassis*, *Pseudambassis*, *Anabas*, and *Trichogaster*
High market value include 24 species belonging to 12 genera	*Chilata*, *Notopterus*, *Osteocheilus*, *Micronema*, *Ompok*, *Wallago*, *Helicophagus*, *Macrognathus*, *Boesemania*, *Oxyelectis*, *Channa*, and *Cynoglossus*
Endangered: 11 vulnerable, near-threatened, endangered, or critically endangered species on the International Union for Conservation of Nature's Red List (IUCN 2021)	*Tenualosa thibaudeaui*, *Lycothrissa crocodilus*, *Probarbus jullieni*, *Probarbus labeamajor*, *Probarbus labeaminor*, *Catlocarpio siamensis*, *Pangasianodon gigas*, *Bagarius yarrelli*, *Glyptothorax fuscus*, *Glyptothorax lampris*, and *Datnioides microlepis* (Fig. 33.3)
Introduced species inhabit the lake and breed in cages or ponds around TSL	*Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Piaractus brachypomus*, and *Oreochromis mossambicus* (Table 33.2; see species numbers 29–32)

Dangila, *Henichorhynchus*, and *Botia* are the most abundant for the longitudinal migration. As these species are typically intolerant to low oxygenated water, they need the open water area of the lake where wind-induced water current oxygenates (Ngor et al. 2018).

The floodplain-resident or non-migratory fish species, by contrast, spend most of their lifespans in the flooded forest (Campbell et al. 2006). The floodplain residents mostly live in the lakes and marshes or swamps on the floodplains near the permanent waterbodies and migrate to flooded areas during the flooded season. The floodplain residents such as *Channa striata* and *Cerberus microlepis* have developed their external organs to breathe the air and thus adapted to the low oxygen and harsh environmental conditions in swamps and small floodplain lakes during the dry season (Poulsen et al. 2002). *C. striata* and all the genera of *Trichogaster* occur predominantly in the northern part of the lake, where the area is predominantly covered by a flooded forest, swampy and shrubland, aquatic vegetation, and rice fields (Chan et al. 2020). The flooded forest areas are also likely important habitats to rear and forage for *Pangasianodon hypophthalmus*, *C. striata*, and *Cyclocheilichthys enoplos* (Chan et al. 2020) because the flooded forests typically constitute an appropriate feeding ground providing a variety of terrestrial prey (e.g., insects, frogs, and small mammals) for opportunistic predators (e.g., *Phalacronotus* spp. and *C. striata*; Poulsen et al. 2004). *C. striata* needs flooded vegetations for breeding and hatching (Rainboth 1996).

Aquaculture is mainly practiced on floating cages attached to houses in TSL and the ponds on non-flooded land. During 2018–2019, TSA inventoried fish farms in 12 large floating villages, i.e., Psar Chhnang, Chhnok Trou, Kampong Luong, Reang

Table 33.2 The fish species of high market value for fresh consumption and exotic species in TSA inventory on fish biodiversity in TSL and its dependency during 2010–2019

	Species	Name[a]	Class	Order	Family	Genus	Habitat[b]	Size[b]	Trophic level[b]	Status	IUCN Red list status[a]	
												Last assessed
1	*Chitala ornata*	Clown featherback	Actinopterygii	Osteoglossiformes	*Notopteridae*	*Notopterus*	pelagic	100.0 SL	3.7	Native	LC	08/30/19
2	*Notopterus notopterus*	Bronze featherback	Actinopterygii	Osteoglossiformes	*Notopteridae*	*Notopterus*	demersal	60.0 SL	3.6	Native	LC	02/09/11
3	*Cyclocheilichthys enoplos*	–	Actinopterygii	Cypriniformes	*Cyprinidae*	*Cyclocheilichthys*	benthopelagic	74.0 SL	3.2	Native	LC	02/09/11
4	*Cirrhinus microlepis*	Small Scaled Mud Carp	Actinopterygii	Cypriniformes	*Cyprinidae*	*Cirrhinus*	benthopelagic	65.0 SL	2.4	Native	VU	02/17/11
5	*Hemibagrus nemurus*	Yellow Catfish	Actinopterygii	Siluriformes	*Bagridae*	*Hemibagrus*	benthopelagic	65.0 SL	3.6	Native	LC	09/01/18
6	*Belodontichthys dinema*	–	Actinopterygii	Siluriformes	*Siluridae*	*Belodontichthys*	Wetlands (inland)	–	–	–	LC	05/30/19
7	*Cryptopterus microneme*	–	–	–	–	–	–	–	–	–	–	–
8	*Wallago attu*	Wallago	Actinopterygii	Siluriformes	*Siluridae*	*Wallago*	demersal	240.0 TL	3.7	Native	VU	08/12/19
9	Pangasius djambal	–	Actinopterygii	Siluriformes	*Pangasiidae*	*Pangasius*	Wetlands (inland)	–	–	–	LC	09/01/18
10	Pangasius larnaudii	Black-spotted catfish	Actinopterygii	Siluriformes	*Pangasiidae*	*Pangasius*	benthopelagic	130.0 SL	3.3	Native	LC	02/26/11
11	*Macrognathus taeniagaster/ Macrognathus semiocellatus**	–	Actinopterygii	Synbranchiformes	*Mastacembelidae*	*Macrognathus*	benthopelagic	16.0 SL	3.3	Native	LC	12/11/19
12	*Macrognathus siamensis*	Spotfin Spiny Eel	Actinopterygii	Synbranchiformes	*Mastacembelidae*	*Macrognathus*	benthopelagic	30.0 SL	3.3	Native	LC	02/24/11

(continued)

Table 33.2 (continued)

	Species	Name[a]	Class	Order	Family	Genus	Habitat[b]	Size[b]	Trophic level[b]	Status	IUCN Red list status[a]	
												Last assessed
13	*Boesemania microlepis*	Smallscale Croaker	Actinopterygii	Perciformes	*Sciaenidae*	*Boesemania*	benthopelagic	100.0 SL	3.7	Native	NT	02/26/11
14	*Oxyeleotris marmorata*	Marble goby	Actinopterygii	Perciformes	*Eleotridae*	*Oxyeleotris*	demersal	65.0 SL	3.9	Native	LC	08/24/18
15	*Channa micropeltes*	Giant Snakehead	Perciformes	Channidae	*Channidae*	*Channa*	benthopelagic	130.0 SL	3.8	Native	LC	12/03/19
16	*Channa striata*	Striped snakehead	Actinopterygii	Perciformes	*Channidae*	*Channa*	benthopelagic	100.0 SL	3.6	Native	LC	01/19/11
17	*Cynoglossus microlepis*	Smallscale tonguesole	Actinopterygii	Pleuronectiformes	*Cynoglossidae*	*Cynoglossus*	demersal	32.5 SL	3.5	Native	LC	01/19/11
18	*Tenualosa thibaudeaui*	Mekong herring	Actinopterygii	Clupeiformes	*Clupeidae*	*Tenualosa*	pelagic	30.0 SL	2	Native	VU	02/22/11
19	*Lycothrissa crocodilus*	Sabretoothed Thryssa	Actinopterygii	Clupeiformes	*Engraulidae*	*Lycothrissa*	pelagic	30.0 SL	3.7	Native	LC	12/02/19
20	*Probarbus jullieni*	Jullien's Golden Carp	Actinopterygii	Cypriniformes	*Cyprinidae*	*Probarbus*	demersal	150.0 SL	3.2	Native	CR	01/29/19
21	*Probarbus labeamajor*	Thicklipped Barb	Actinopterygii	Cypriniformes	*Cyprinidae*	*Probarbus*	benthopelagic	150.0 SL	2.5	Native	EN	02/25/11
22	*Probarbus labeaminor*	Thinlip barb	Actinopterygii	Cypriniformes	*Cyprinidae*	*Probarbus*	Wetlands (inland)	–	–	–	NT	02/25/11
23	*Catlocarpio siamensis*	Giant barb	Actinopterygii	Cypriniformes	*Cyprinidae*	*Catlocarpio*	benthopelagic	300.0 TL	2.9	Native	CR	04/05/11
24	*Pangasianodon gigas*	Mekong giant catfish	Actinopterygii	Siluriformes	*Pangasiidae*	*Pangasianodon*	benthopelagic	300.0 TL	2.3	Native	CR	04/13/11
25	*Bagarius yarrelli*	–	Actinopterygii	Siluriformes	*Sisoridae*	*Bagarius*	Wetlands (inland)	–	–	–	VU	06/06/19
26	*Glyptothorax fuscus*	–	Actinopterygii	Siluriformes	*Sisoridae*	*Glyptothorax*	Wetlands (inland)	–	–	–	LC	06/04/19

27	*Glyptothorax lampris*	Torrent catfish	Actinopterygii	Siluriformes	*Sisoridae*	*Glyptothorax*	benthopelagic	12.1 SL	3.2	Native	LC	05/06/11
28	*Datnioides microlepis*	Finescale tigerfish	Actinopterygii	Perciformes	*Datnioididae*	*Datnioides*	benthopelagic	45.0 SL	3.6	Native	LC	08/09/19
29	*Cyprinus carpio*	Common carp	Actinopterygii	Cypriniformes	*Cyprinidae*	*Cyprinus*	benthopelagic	120.0 TL	3.4	Exotic	VU	01/01/08
30	*Hypophthalmichthys molitrix*	–	Actinopterygii	Cypriniformes	*Cyprinidae*	*Hypophthalmichthys*	Wetlands (inland),Artificial/Aquatic	–	–	Exotic	NT	01/20/11
31	*Piaractus brachypomus*	–	Actinopterygii	Characiformes	–	–	–	–	–	Exotic	–	–
32	*Oreochromis mossambicus*	Mozambique Tilapia	Actinopterygii	Perciformes	*Cichlidae*	*Oreochromis*	Wetlands (inland),Artificial/Aquatic	–	–	Exotic	VU	10/02/17

Note: LC, VU, NT, EN, and CR denote less concern, vulnerable, near-threatened, endangered, and critically endangered, respectively. The sign "–" denotes not available; SL, standard length (cm); TL, total length (cm); trophic level, the trophic position of a fish in the food web. Source: [a] ICUN Red List, [b] FishBase (Froese and Pauly 2021), * Synonyms

Til, Kampong Khlaeng, Kampong Phluk, Chong Khneas, Me Chrey, Prek Toal, Prey Chas, Peam Bang, and Phat Sanday. Approximately 6520 cages and 210 ponds have been designed for fish aquaculture, and 650 cages are for crocodile farms. The main fish species reared include *C. striata*, *Channa micropeltes*, *Clarias* spp., *Pangasius* spp., and *Hemibagrus wyckioides*. Fish aquaculture around TSL produces around 14,000 tons/year and can be sold fresh for consumption.

33.3 Reptiles

It has been reported that 46 species of reptiles inhabit TSL's ecosystem (Bonheur and Lane 2002). The Tonle Sap Biosphere Reserve supports internationally significant populations of at least eight globally threatened reptile species, including the critically endangered Siamese crocodile *Crocodylus siamensis*; at least six species of freshwater turtle, including the endangered yellow-headed temple turtle *Heosemys annandalii*; and the near-threatened Burmese python *Python molurus* (Davidson 2006).

The majority of snakes are semi-aquatic homalopsid water snakes, previously known as *homalopsines* (Brooks et al. 2007; Lawson et al. 2005; Saint Girons and Pfeffer 1972). Brooks et al. (2007) reported 11 species of snake from 5 families, viz., Homalopsidae (*Enhydris enhydris*, *Enhydris longicauda* (Fig. 33.4a), *Homalopsis buccata*, *Erpeton tentaculatum*, *Enhydris bocourti*, and *Enhydris plumbea*), Colubridae (*Xenochrophis piscator* and *Cylindrophis ruffus*), Elapidae (*Naja kaouthia/siamensis*), Boidae (*Python molurus*), and Acrochordidae (*Acrochordus granulatus*). Most of the species are restricted to vegetated areas, with their catches higher in the flooded grassland than in other habitats, except for *Erpeton tentaculatum* and *E. plumbea*. Species such as *E. enhydris* and *Cylindrophis ruffus* were very occasionally caught in the open water of the lake. Only three individuals of *Acrochordus granulatus* were recorded in the open lake (Brooks et al. 2007). *E. plumbea* showed the highest catch per unit effort in deep water. All of the other species showed significant negative relationships between catch per unit effort and water depth.

Crocodile (*Crocodylus siamensis* or local name Kra peu trey) is present in both the crocodile farm and the TSL floodplain. Within the TSL basin, there has been a substantial boom in the local crocodile farm industry, and approximately 600 crocodile farms exist around TSL. Local people breed and rear the native Siamese crocodile (*Crocodylus siamensis*, Fig. 33.4c) and the non-native Cuban crocodile (*Crocodylus rhombifer*) for commercial purposes (Campbell et al. 2006).

Varanus salvator (local name: An sorng, Fig. 33.4d) lives in the flooded forests around TSL, spawning in the hole of big trees during the rainy season. Around TSL, this species has become very rare and is caught by the fisherman only in the Prek Toal Biosphere Reserve. This species has been classed in CITES Appendix II of the Convention in International Trade in Endangered Species of Wild Fauna and Flora (CITES), for trade control to avoid utilization incompatible to its survival.

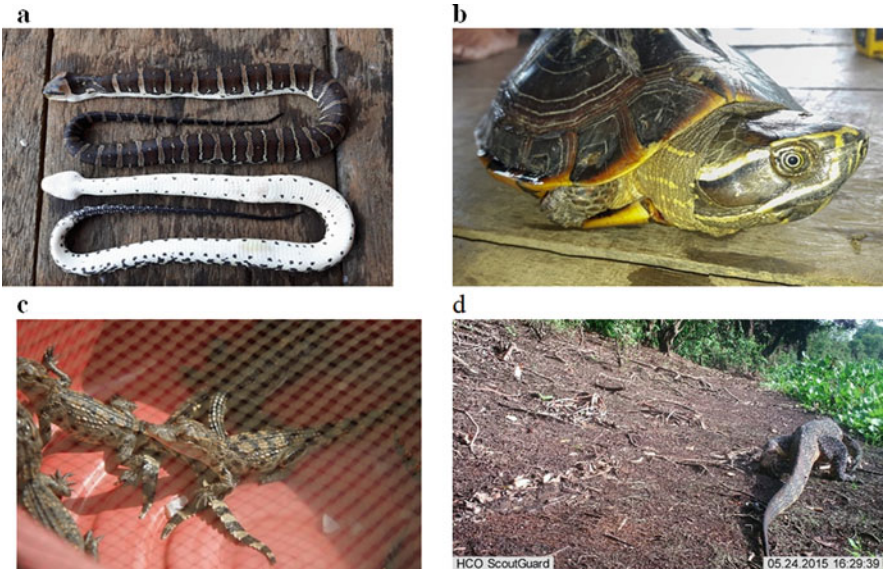

Fig. 33.4 (**a**)[1] Tonle Sap water snake *Enhydris longicauda* (local name: Pous ph'ab), (**b**)[1] Yellow-Headed Temple Turtle *Heosemys annandalii* (local name: Song Kal), (**c**)[1] Crocodile *Crocodylus siamensis (*local name*:* Kra peu trey), and (**d**)[2] *Varanus salvator* from a camera trap in 2015 (local name: An sorng). Photo credit ([1]author; [2]Sun Visal)

At least six species of turtles have been confirmed in TSL (Davidson 2006). In 2018–2019, TSA inventoried different turtles in TSL through surveys in floating villages with people living there since the 1980s. As a result, seven turtle species were identified, viz., yellow-headed temple turtle *Heosemys annandalii*, rice-field terrapin *Malayemys subtrijuga* and Asiatic soft-shell turtle, Asian box turtle *Cuora amboinensis*, black mash turtle *Siebenrockiella crassicollis*, Asiatic soft-shell turtle *Amyda cartilaginea*, and P'dao kramoun (no scientific name available yet). The spawning period of most turtles starts from November to January when the water level in TSL recedes and in the rainy season from July to August for the Asian soft-shell turtle.

33.4 Mollusca and Arthropod

After fish, Mollusca are the second most important contributor to food provisioning in TSL (Rainboth 1996). According to MRC (2003), bivalves (e.g., Asian clam *Corbicula* spp., Fig. 33.5a) are abundant in the dry season, but people start harvesting it at the end of the rainy season, whereas gastropods (e.g., apple snails *Pila* spp.) are abundant in the beginning of the rainy season and in the beginning of the dry season, when floodwaters recede and the water temperature reaches its

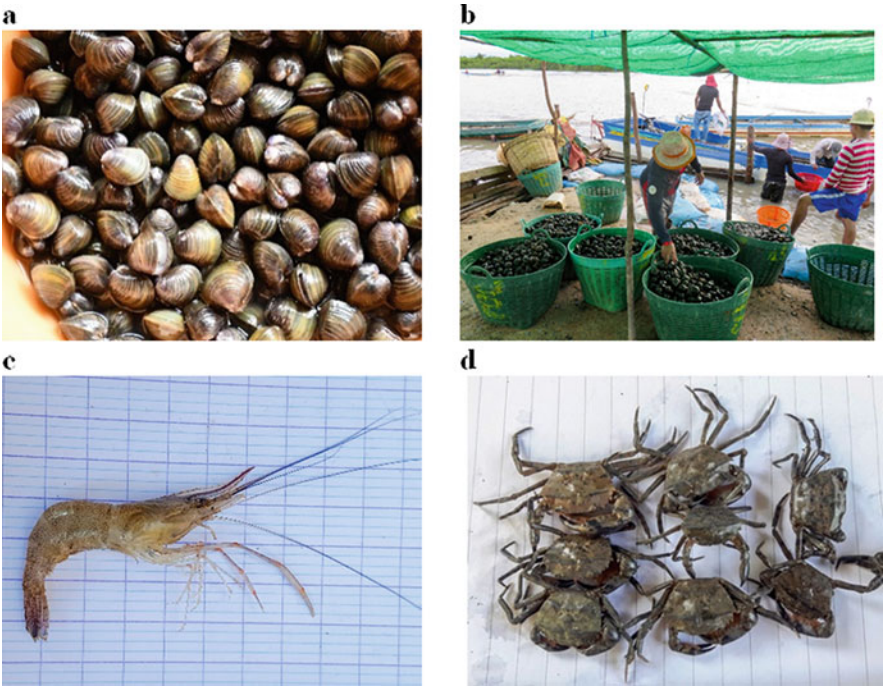

Fig. 33.5 (**a**) Asian clam *Corbicula moretiana* (local name, leas; class, Bivalvia; family, Corbiculidae), (**b**) snail *Pila polita* (local name: k'chorng boeng), (**c**) freshwater shrimp *Neocaridina* spp. (local name, Kam peus touch/angkam; family, Atyidae), and (**d**) crab *Siamthelphusa improvisa* (local name, Kdam mouk yeak; class, Malacostraca; family, Gecarcinucidae)

minimum in the year. The report from Ting et al. (2020) recorded 33 Crustacea and Mollusca species in TSL.

Our surveys in TSL from 2018 to 2019 found 31 species, 15 bivalves (5 families), and 16 gastropods (8 families), including three new records for Cambodia (i.e., *Scaphula minuta*, *Novaculina siamensis*, and *Wattebledia siamensis*), a globally invasive species such as *Pomacea maculata* and *Limnoperna fortune*, which modifies the presence and abundance of native macro-invertebrate fauna and fish diets and changes the ecological condition (Boltovskoy 2015).

Until now, the estimation of catch and trade of Gastropoda in TSL has not been assessed. The preliminary inventory by TSA on the caught snail for sale at the local markets and for export from the six provinces around the lake indicated that snails were caught by rudiment and a landing net. The period of snail collection starts in the beginning of the rainy season when the water levels rise. Five species from two families were identified, including Viviparidae [*Melongirapongeasis aeruginasesaiy* (local name: Ka chav), *Filopaludina martensi cambodjensis* (local name: Ka chav Ka'ek/Ka chav kut srouch), *Mekongina phaericula* (local name: Ka chav doung)]

and Pilidae [*Pila polita* (local name: k'chorng boeng, Fig. 33.5b) and *Pila scutata* (k'chorng boeng krang/kut teal)].

Freshwater shrimps are dominant in the upper and the middle of TSL and near the organic substrate-rich shoreline. Their exploitation is typically practiced from December to June when the water level of TSL is between 2 and 3 m. Four main species were recorded: *Macrobrachium nipponense* (Kam peus), *Macrobrachium lotidachylus* (Kam peus), *Macrobrachium ohione* (Kam peus dai thom), and *Neocaridina* spp. (Kam peus touch/angkam) (Fig. 33.5c). The freshwater shrimp is sold fresh for consumption and processed as dried shrimp. In 2019, the estimated total annual catch of Crustacea (e.g., Crab *Siamthelphusa improvisa*, Fig. 33.5d) in TSL was approximately 59 tons. Different fishing gears and traps are mostly brush bundle for shrimp.

Key Points

- TSL and its surrounding floodplains form heterogeneous habitats, including flooded forests, shrubs, grasslands, and aquatic vegetations. These provide the variety of habitat for aquatic fauna to accomplish a large part of their life cycle and support high biodiversity and productivity.
- For fish, 167 species, belonging to 12 orders, 35 families, and 94 genera, were identified in the inventory on fish biodiversity in TSL and its floodplains in 2010–2019, approx. 75% of which belong to the order Cypriniformes, Siluriformes, and Perciformes.
- The migratory fish species access the seasonally flooded habitats to feed and grow during the wet season, whereas the floodplain-resident or non-migratory fish species spend most of their lifespans in the flooded forests.
- TSL is also home to at least 15 species of bivalves, 16 gastropods, 11 snake species, 7 turtle species, and other arthropod species.

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