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The ecological habitats and density of invasive Apple Snail *Pomacea canaliculata*, Lamarck,1822 (Gastropoda: Ampullariidae) at the banks of Shatt Al-Arab River, Basrah, Iraq

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ABSTRACT

The ecological habitats and density of snails *Pomacea canaliculata* were studies in two sites in intertidal zone at banks Shatt-Al-Arab river, Basrah, Iraq. The Snails were collected randomly by 1x1m-quadrats monthly three sampling quadrats in the month for 12 months from December 2013 to November 2014. Density of snails include stages (juvenile and adult), sex ratio, egg clutch density, and number of eggs per clutch were recorded. The results showed that snail population fluctuated and depended on the seasons of the year. Snail density in two sites was .(43ind./m^2 in April 2014) and (0 ind./m^2 in December 2013 to February 2014). Sex ratio showed lower number of males than females for sites 1,2 (1:1.09-1:5.04) except for sites 2 for April month (1.14:1). Egg clutch density ranged from 0-3 m^2 with a clutch size of 61-576 eggs. These densities of simply high population growth rate.

Keywords: Golden apple snail, invasion, , Shatt Al-Arab river.

Introduction

Freshwater snails *P. canaliculata*, is found in ponds, lakes, creeks, rivers, streams and irrigation systems, particularly in rice fields [1; 2]. is an aquatic gastropod that belongs to the ampularidae family are noteworthy, anatomical, physiological and ecological characteristics [3], which have a scientific interest for long ago. However, few studies had focused on apple snail population dynamics[4; 5]. International concern about the Argentinean apple snail *P. canaliculata* (Lamarck, 1822) rose enormously when it became established as a serious rice pest in Asia. *P. canaliculata* are freshwater snails that could be easily found especially in the water irrigation system of paddy fields and local wetlands. It was initially entered Asia in 1980s [6] Due to their extensive reproductive capacity which causes a huge damage to the rice fields and wetlands in 18 countries, the snails are classified as one of the 100 world worst invasive pest species [7]. Currently, many methods have been developed and employed to control the invasion of the snails which uses the integration of multidiscipline approach [8]. IPM strategies which include mechanical [9; 10], physical [11; 12], chemical [13; 14) and biological control [15; 16] have been claimed to be effective.

The genus *Pomacea* is native to South and Central America, parts of the Caribbean, and the southeastern U.S. It has become widely established in many areas within Southeast Asia, Sri Lanka, Guam, Hawaii, Papua New Guinea, the Dominican Republic, parts of the mainland U.S., and possibly Australia [17; 18]. The introductions of these snails have resulted mostly escape or release from plant or animal aquaculture operations or through the pet trade [19).

Golden apple snail *Pomacea canaliculata* is non-native gastropod to Asia continent and it is believed to be native to Argentina [18; 20]. It was introduced to Taiwan as human food [21] however; it became a pest of agricultural fields and brought great economic losses (22). They have high reproduction rate and can even survive harsh environmental conditions such as pollution or low oxygen levels. They have demonstrated a tenacious ability to survive and spread rapidly in the freshwater habitats into which they have been introduced [21]. In result it is widely distributed throughout Asia [23].

This study aimed to determine the presence, abundance and to analyze the information on *P. canaliculata* life history and fecundity in two sites at selected intertidal zones ponds of banks Shatt-Al-Arab river, at Al-Salyhea station, Basrah, Iraq and to review the effect of some factors on survivorship and reproduction of this remarkably plastic snail in two sites at Al-Salyhea station in Shatt Al-Arab River .

MATERIALS AND METHODS

Study sites:

Sampling was conducted from two sites at Shatt al- Arab banks on the entrance of the River of Salyhea Station, N 30 ◦ 51'. 66.2" E 047◦ 85.5'. 48" against the Al-Sadr teaching hospital into Al-Salyhea Island against Presidential Palace [Figure 1). site 1 north of site 2, site 1 is far of the site 2 about 1km, Site 1- pond with water vegetation's, Site 2- one branch connected into Shatt Al- Arab river.

Figure (1). Map of the study sites near Al-Salyhea canal.

Samples collection and measured some environmental factors:

The snails were collected through two sites. The banks of Shatt Al- Arab river was an area with ponds near the Salyhea canal. Selected one of these ponds that have a bottom of a thin layer of mud and sand, with organic matter, roots of aquatic weeds (reeds and other macrophytes), and selected other site that one branch connected to Shatt Al-Arab with a bottom consisted of stones and other materials .

To estimate snail density we applied "quadrat Count" by used a quadrat PVC frame of 1 x 1 m as a quadrat following [24]. To monitor changes in snail population at this sites" a simple random sampling was conducted on monthly interval between December 2013 and November 2014 three sampling quadrats were randomly placed After that, searching for snails by hands and counting were carried out at low tidal period. These specimens were brought to the laboratory where all animals were kept in aquarium for identifications and study.

snails were classified and counted. Egg clutch were also counted as well as the number of eggs per clutch. The sex of the individual snails was also identified based on the description of Mahilum and Demayo[25]

The collected snails were measured according to Estebenet and Martín [26]. The identification was based on shell morphology [27] and by the features of the egg clutches [28], picture 1.

The physical and chemical parameters that were taken in the field by multi meter yasi including pH, water temperatures, dissolved O_2 and salinity.

Different body measurements including shell length, width and aperture length and width were measured as per given measurement details (Figure 2) The weight of the animals was measured with an electric balance.

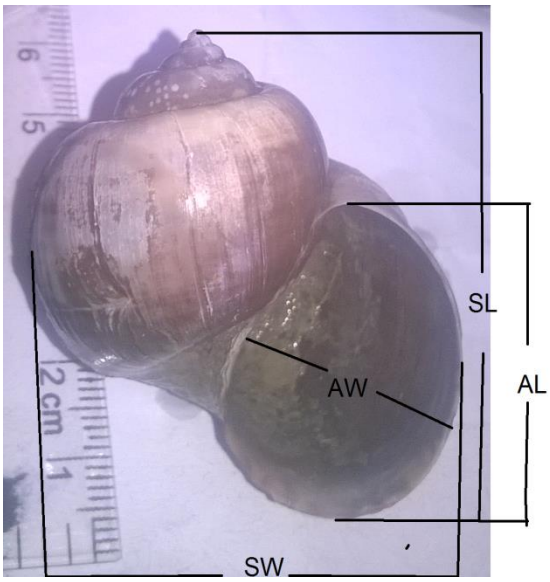

Figure 2. the measurements of *P. canaliculata* shell,
S.L= Shell Length, S.W= Shell Width, A.L= Aperture Length, A.W=Aperture Width.

Picture 1. Specimen of *Pomacea canaliculata* and eggs clutch

Results

The values of the water parameters did not differ among the sampling stations (ANOVA, $p > 0.05$). Dissolved oxygen and pH ranged from 8.4 to 4.7 mg/l and from 7.12 to 7.82, respectively, and pH showed no variation among study months. Salinity differed significantly among study months, with the lowest levels recorded during the winter months and the highest during the summer months (Tukey, $p < 0.05$). The temperature was significantly lower during the winter months (9 ◦C) than during the summer months (34 ◦C) . (Tukey, $p < 0.05$).

The snail lives in rather wide range of water temperatures during summer when the air temperature rises above 40 °C, the snail was distributed in the intertidal zone sites at

the banks of Shatt Al-Arab river which have relatively range of temperatures of 9-34 °C . At the end of autumn and in winter, when the air temperature falls down sharply, the snail decreases its distribution and retreat to ponds areas which keep their preferable temperatures.

Table 1. Some physical and chemical in the two sites of intertidal zone at the banks of the Shatt Al- Arab river.

Months	Water temp.(°C)		Dissolved O_2 (mg/L)		Salinity ‰		pH	
	Site 1.	Site 2.	Site 1.	Site 2.	Site 1.	Site 2.	Site 1.	Site 2.
Dec. 2013	11	11	7.2	6.3	2.1	2.2	7.12	7.15
Jan. 2014	9	10	8.3	7.3	1.8	2.4	7.23	7.26
Feb. 2014	14	16	7.3	6.4	1.5	1.6	7.15	7.18
Mar. 2014	18	21	6.7	5.1	1.2	1.5	7.34	7.37
Apr. 2014	23	24	7.4	5.8	1.1	1.2	7.47	7.48
May 2014	26	27	6.2	5.6	1.0	1.2	7.36	7.40
Jun. 2014	29	30	5.2	4.9	2.3	2.3	7.62	7.59
Jul. 2014	31	33	5.6	5.2	4.4	4.5	7.82	7.81
Aug. 2014	32	34	5.0	4.7	5.1	5.4	7.56	7.73
Sep. 2014	31	32	5.7	5.0	4.5	4.4	7.49	7.56
Oct. 2014	28	28	6.9	5.7	3.8	4.2	7.18	7.21
Nov. 2014	26	27	7.5	5.5	2.9	3.1	7.16	7.17

Snail density in the sampling area ranged from 0 to 43 individual m^2 for all study months (Table 2). Highest densities were recorded at all study months in site 1, while the lowest densities observed at site 2 in most of the months of winter season from December 2013 and February 2014.

Table 2: Population density (Individual/ m^2) of *P. canaliculata* during Dec. 2013 to Nov. 2014 in two sites at intertidal zone of Shatt Al-Arab river.

Months	Site 1. ind. /m^2	Site 2. ind. / m^2
Dec. 2013	12	0
Jan. 2014	11	0
Feb. 2014	16	0
Mar. 2014	34	3
Apr. 2014	43	0
May 2014	33	4
Jun. 2014	32	2
Jul. 2014	22	0
Aug. 2014	34	4
Sep. 2014	18	3
Oct. 2014	20	1
Nov. 2014	12	0

Male to female ratio in the sampling area range from (1:1.09-1:5.04) for site 1, and (1:1,06-1:1.2.24) for site 2, with more females than males except for sites 2 (1.14:1) in April month2014. In addition, egg clutch density was recorded within the range of 0-3 m^2 (Table 3) while eggs per clutch ranged from 61-576 eggs.

Table 3. Egg clutch density of Pomacea canaliculata in selected two sites at intertidal zone of Shatt Al-Arab

river from December 2013 to November 2014.

Months	Site 1. Egg clutch /m²	Site 2. Egg clutch/ m²
Dec. 2013	0	0
Jan. 2014	0	0
Feb. 2014	0	0
Mar. 2014	2	0
Apr. 2014	3	0
May 2014	1	1
Jun. 2014	2	1
Jul. 2014	1	1
Aug. 2014	2	1
Sep. 2014	1	1
Oct. 2014	2	1
Nov. 2014	2	1

Coloration: The color of body was yellow to brown, with horizontal black lining. In younger animals the black strips were wider than that of the older ones. These black strips narrow gradually as the snails grow. In adults the body color becomes yellowish golden with brown tinge.

Shell size: The shell length (SL) varied from 28.86 to 71.34 mm. The shell width (SW) showed a range from 18.54 to 55.96 mm wide depending on the season of the year. The operculum (aperture) is large and oval; it varied in length from 15.17 to 44.43 mm whereas its width ranged in between 15.24-42.93 mm.

All the body measurements were showed a significant positive relationship among all, the SL and OL (operculum length) showed a maximum linear correlation r=0.93 Table 4.

Table 4. Linear Regression (coefficient of determination) for body measurements relationship.

S. No.	Measurements	r	S. No.	Measurements	r
31	SL V/S SW	0.90	23	SW V/S AW	0.52
21	SL V/S AL	0.93	22	AL V/S W	0.73
18	SL V/S AW	0.75	16	AL V/S AW	0.64
24	SW V/S AL	0.72	28	SW V/S W	0.70

W= weight, S.L= shell length, S.W= shell width, A.L= aperture length, A.W= aperture width,,

Discussion

Golden apple snail was introduced to Asia through Taiwan in 1979. Since then it has been expanding in Asia and at present it invaded most of the Asian countries in three decades [18). The invasion of *P. canaliculata* in Shatt Al-Arab river, Basrah was probably a result of the pet trade.

This snail impacted in this area by many threats such as agriculture, exploitation of groundwater, water transfer schemes and pollution of surface and groundwater. This agrees with the findings of [20]. [18] mentioned that *P. canaliculata*, which he refer to it as *P. canaliculata*, was widely distributed in a variety of aquatic habitats on stones and certain aquatic plants like *Ceratophyllum demersum*.

The wide distribution of *P. canaliculata* suggests its great plasticity endogenous and exogenous factors [29], a feature repeatedly seen in the invaded areas of Southeast Asia,

demonstrating its great adaptive capacity. *P. canaliculata* can disperse rapidly and – according to habitat characteristics – can adjust his life by changes his reproductive cycle, feeding and growth pattern. Thus it achieves population settlement [30]. Likewise, natural predators are missing in the invaded areas [31].

The abundance of *P. canaliculata* recorded in two sites at banks of Shatt Al-Arab lower compared with most reports of natural populations of *Pomacea*. If the abundance of this species is expressed in ind/m^2 to allow comparisons with other studies, the highest density in current study was only 43 ind/m^2. Similarly, The densities of the invasive *P. canaliculata* Lamarck ranged from 25.6 to 42.7 ind/m^2 in Hong Kong [32] and reached values of more than 130 ind/m^2 in Hawaii [17]. [33] reported very low densities [0.05-1 ind/m^2) of *P. paludosa* Say from Florida wetlands. and the density of *P. haustrum* Reeve ranged from 20 to 215 ind/m^2 [34]. A plausible explanation for the low estimated abundance of *P. flagellata* in Guerrero Lagoon is that the values reported are underestimates due to errors in the sampling method. During the study period,

no previous data on the abundance of the species are available to confirm this suggestion. Salinity levels might also explain the low density of this species, as they have been reported to limit the distribution and abundance of other apple snails [i.e., *P. bridgesii* Reeve and *P. insularum*), with tolerance levels of 6.8 psu [35; 17; 36].

Golden apple snails have a high fecundity and reproduce rapidly with the considerable range of eggs per egg clutch [37]. In the present study a density of 0-3 egg clutch per m^2 with an average of 264 eggs per clutch was recorded. The latter is within the range of 92 to 592 eggs recorded by Teo [20] in a similar study wherein most egg masses had more than 200 eggs; egg masses with fewer than 100 eggs were rare and egg clutch with 500-600 eggs were frequent. Furthermore, a study by Kyle *et al.*[1] reported that *P. canaliculata* clutch size conservatively never exceeded 400 eggs but notably, Tanaka *et al.*[38] documented up to 3,000 eggs in a clutch in Asia.

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بيئة الموطن والكثافة لقوقع التفاحة الذهبية الغازي *Pomacea canaliculata* من ضفاف شط العرب, البصرة–العراق

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خلاصة

درست بيئة الموطن والكثافة لقوقع التفاحة الذهبية *Pomacea canaliculata* في ثلاثة مواقع في منطقة المد والجزر عند ضفاف شط العرب, بصرة, عراق.

أما لدراسة كثافة القواقع، فقد أخذت عينات القواقع في الحقل ثلاث مكررات شهرياً وبشكل عشوائي على التوالي بواسطة مربع خشبي 1x1m–quadrats لمدة 12 شهرا من كانون الاول 2013 إلى تشرين الثاني 2014. وأظهرت النتائج أن عدد السكان الحلزون تذبذب ويعتمد على الفصل من السنة. وسجلت كثافة النوع والنسبة الجنسية وكثافة عنقود البيض وعدد البيض لكل عنقود. وأظهرت النتائج تذبذب تجمع القوقع وأعتماداً على الفصل من السنة . وكانت كثافة القوقع (43 فرد/م^2 في نيسان 2014) و(0 فرد/م^2 في أشهر من كانون الاول 2013 الى شباط 2014). وأظهر معدل النسبة الجنسية العدد الاقل للذكور من الاناث (1:1.09–1:5.04) للموقعين 1و2 باستثناء المعدل للموقع 2 في شهر نيسان 2014 (1:1.14). المدى لكثافة عنقود البيض من 0–3 م^2 مع حجم العنقود ضمن المدى 61–576 بيضة. هذه الكثافات ببساطة تفسر معدلات نمو التجمعات العالية

الكلمات المفتاحية: التفاحة الذهبية غزو القوقع،، نهر شط العرب.