Some Biology and Ecological Risk Assessment of Crayfish on Freshwater Resources and Establishment of Crayfish in Pra Pong reservoir, Sra Keaow Province

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Abstract

Crayfish are invasive species that have been introduced to Thailand since 1987 for aquaculture and ornamental fish industry purposes. However, its impact on freshwater natural resources of Thailand is not known. Therefore, the aims of this study were to investigate biology and life history of *Procambarus clarkii* and to assess potential effects of crayfish on indigenous flora and fauna. Field survey was also carried out to indicate establishment of *P. clarkii* in a natural habitat. The results revealed that *P. clarkii* laid eggs after two weeks of hatching and had high fecundity of approximately 180-300 eggs per individual. Reproductions took place three times during experiments (30 weeks). Furthermore, adult female crayfish molted approximately 11 times whereas male crayfish did not molt and thus having smaller body sizes than female crayfish. In term of food sources, *P.clarkii* fed on both freshwater macrophytes and animals. In particular, *P. clarkii* consumed large amount of *Hydrilla verticillata* and rice (*Oryza sativa*). Native fauna such as juvenile *Channa striata* and *Macrobrachium lanchesteri* were also hunted by *P. clarkii*. In contrast, snails (*Filopaludina martensi*) were least eaten since they possess hard shell to protect themselves from predation. Our field survey using fish traps overnight also revealed an interesting finding that crayfish species of *Cherax quadricarinatus* (highly invasive) have already established in Pra Pong reservoir, Sra Keaow Province.

Keywords

Biological Control, Crayfish, Introduced Species, Invasive Species, Thailand

Introduction

Crayfish are freshwater crustaceans resembling small lobsters. They are taxonomically members of the super families Astacoidea and Parastacoidea. They are reported as invasive alien species in many countries such as Singapore (Shane and Darren, 2007; Christina and Darren, 2010), Italy (Francesco *et al.*, 2009) and Mexico (Jose *et al.*, 2007).

There are several studies indicating that crayfish are serious threats to fresh water ecosystem (Lynne *et al.*, 2006; Francesco *et al.*, 2009; Massimiliano *et al.*, 2010). Patrik and Per (2003) found that the introduced signal crayfish may affect stream communities directly and indirectly. Invaded communities will have reduced macroinvertebrate taxon richness and the signal crayfish will replace vulnerable invertebrate predators such as leeches. Interestingly, there is also a clear evidence of reduced species numbers in areas containing crayfish. Especially, densities of Plecoptera, Hirudinea, Tricladida and Hydracarina were reduced. The study of a limestone headwater stream in the Pennine uplands, Yorkshire showed a significant negative relationship between the fish and signal crayfish (Peay S. *et al.*, 2009). Crayfish also influence aquatic macrophytes. Anastácio *et al.*, (2000) reported that there was a total destruction (100%) of rice in enclosures with densities of 3 and 5 crayfish m^{-2}.

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In Thailand, crayfish were introduced for the first time in 1987 for aquaculture purposes (Kannasuit, 2006). There are at least two species including *Procambarus clarkii* and *Cherax quadricarinatus* that are reported to present in Thailand. Currently, crayfish are regarded as invasive species by Office of Natural Resources and Environmental Policy and Planning, 2006; Office of Natural Resources and Environmental Policy and Planning , 2009; Department of fisheries, 2010). The species of *Cherax quadricarinatus* (Von, 1868) is found in Buriram, Sisaket, Kanchanaburi and Chiangmai provinces and the species of *Procambarus clarkii* (Girard, 1852) is discovered in Kwaiyai and Kwainoy rivers, Kanchanaburi province (Vidthayanon C., 2006).

The objectives of this study were to determine biology and life history of crayfish as well as investigating potential impacts of crayfish on freshwater natural resources. Field survey was also done to indicate the establishment of crayfish in a natural habitat of Thailand.

Methodology/Experimental design

Biology and life history

Crayfish, *Procambarus clarkii*, approximately six to seven cm (two months old) were raised in glass aquaria (12.5x25x17.5 cm). We measured water quality prior to the beginning of the experiment. Parameters were temperatures (28.64±0.28 ºC), pH (7.23±0.01), dissolved oxygen (DO) (7.79±0.03 mg/l), biological oxygen demand (BOD) (1.15±0.01 mg/l), total dissolved solid (TDS) (210.21±16.19 mg/l) and electrical conductivity (401.02±16.07 µS/cm). In laboratory we raised crayfish together at a 1:1 ratio of male and female. Crayfish were fed with pellets daily. Measurement of growth rate (weight and length) of crayfish was conducted every week for 30 weeks. We also recorded the number of molting and hatching eggs as well as observation of behaviors. The experiment was repeated five times.

Impacts of crayfish on freshwater resources

Crayfish (*P. clarkii*) at the age of one month old were used in aquaria (average length 4.78±0.42 cm). Eight types of freshwater macrophytes and animals were offered to crayfish namely *Oryza sativa*, *Hydrilla verticillata*, *Ceratophyllum demersum*, *Macrobrachium lanchesteri*, *Oreochromis niloticus*, *Channa striata*, *Pomacea canaliculata* and *Filopaludina martensi*. The food was weighed (grams) weekly before and after providing to *P. clarkii*. Measurement of growth rates (weight and length) and food consumption of crayfish was conducted every week. The experiment was repeated and lasted for seven weeks.

Field survey

Sampling of crayfish was conducted in Pra Pong reservoir, SraKeaow Province. Measurement of water quality included temperature, pH, DO, electrical conductivity, TDS and transparency. Five traps (diameter of 25.5 cm, circumference 84 cm and length of 45.5 cm) with dead fish inside to attract crayfish were placed overnight along the shoreline at five stations with interval of 50 meters apart. Any crayfish found in traps after thriving was recorded and identified.

We used Excel 2007 and SPSS Statistic 16.0 software packages for Statistic analyses. One-way ANOVA was applied to determine differences between growth rates and food consumption. Data presented throughout were mean±standard deviation.

Results and Discussion

Biology and life history

The results showed that crayfish molted 11 times throughout the experiment. Molting lasted approximately 15-20 minutes. After molting, external shell of

crayfish were soft but soon became hard again in two to three days. In addition, it was found that crayfish mating happened three times. Male crayfish approached the female from behind and flipped a body of female with hooks and then the male started mating with the female. Mating took 10-20 minutes. After 1-2 weeks, egg clusters developed and apparently appeared under abdominal part of the female (Figure 1). Egg is a black sphere about 0.2 cm in diameter. Each cluster was composed of 180 to 300 eggs per individual (Figure 1). This is consistent with Rohasrisakul (2010) revealing that crayfish laid 300 eggs per individual. However, hatching was not successful under laboratory conditions. At the end of experiment, crayfish males and female were aged 26 and 30 weeks, respectively. Female crayfish had total length of 9.83±0.68 cm and weight of 30.83±699 in comparison with male crayfish having total length of 7.68±0.22 cm and weight of 15.91±2.95 g. Male crayfish did not molt and therefore making them smaller than female. Molting helps enlarge body sizes of the crayfish (David, 2002).

Figure 1. Clutch of eggs on female crayfish (*P. clarkii*) in the laboratory

Impacts of crayfish on freshwater resources

Eight types of freshwater macrophytes and animals called *O. sativa, H. verticillata, C. demersum, M. lanchesteri, O. niloticus, C. striata, P. canaliculata* and *F. martensi* were offered to crayfish. It was found that crayfish could consume all freshwater macrophytes and animals offered. In particular, crayfish preferably fed on *H. verticillata* (28.77±12.47 g) and rice (*O. sativa*) (18.54±3.54 g) (Table 1). In addition, native fauna such as juvenile *C. striata* and *M. lanchesteri* were also consumed by crayfish. In contrast, snails (*F. martensi*) were not much eaten because of possessing hard shell to avoid predation.

Reduction of freshwater resources caused by crayfish is apparent as indicated by several studies. Francesca and Patrizia (2007) found that crayfish (*Procambarus clarkii*) consumed both animals and plants such as *Haitia acuta* and *Potamogeton filiformis*. Lynne *et al*. (2006) and Nilssin *et al*. (2012) also reported that the amounts of invertebrates were reduced in water bodies where crayfish have invaded. Furthermore, Gentile *et al*. (2012) suggested that there was a direct negative impact of introduced crayfish on communities of amphibian and insect predators. Crayfish can also prey on juvenile sea trout (*Salmo trutta*), Atlantic salmon (*S. salar*) and brown trout.

Table 1 also shows average daily growth rate and food conversion ratio. It was found that crayfish consuming *M. lanchesteri* performed the highest growth rate. In addition, crayfish feeding on *P. canaliculata* had the lowest food conversion food ratio meaning of an animal's efficiency in converting feed mass into increased body mass. Thus *P. canaliculata* having a low FCR is considered efficient users of feed.

Table 1 Consumption, average daily growth rate and food conversion ratio of crayfish that consumed freshwater macrophytes and animals during 7-week experiment

Freshwater Resrouces	Consumption (g)	Average Daily Growth Rate, ADG (cm/day)	Food Conversion Ratio :FCR
Oryza sativa	18.54 ± 3.54	0.02 ± 0.31	16.3 ± 10.68
Hydrilla verticillata	28.77 ± 12.47^{abc}	0.02 ± 0.03	21.09 ± 5.47^{ab}
Ceratophyllum demersum	12.96 ± 2.5	0.02 ± 0.03	4.68 ± 0.28
Macrobrachium lanchesteri	12.76 ± 5.51	0.06 ± 0.17	4.87 ± 4.38
Oreochromis niloticus	12.35 ± 9.03	0.01 ± 0.02	5.36 ± 4.67
Channa striata	13.13 ± 4.57	0.02 ± 0.04	9.31 ± 8.08
Pomacea canaliculata	3.51 ± 1.54^{ab}	0.02 ± 0.03	2.27 ± 1.66
Filopaludina martensi	0.04 ± 0.04^{ac}	0.01 ± 0.03	0.03 ± 0.01^{ab}
Control (fed with the pellets)	9.8±0.05	0.06 ± 0.56	5.4 ± 2.63
P-value	>0.01	0.17	0.03

Field survey

For the first time, our field survey using fish traps left overnight in May 2013 indicated establishment of crayfish in Pra Pong reservoir. A crayfish species of *Cherax quadricarinatus* was the only species found (4 individuals) (Figure 2). It is of concern that this species may influence local flora and fauna. This is because in many countries *C. quadricarinatus* has seriously caused many negative changes in biological communities (Christina and Darren, 2010; Gregory and Bella, 2011). Crayfish also has an impact on irrigation structures and man-made water bodies such as reservoirs. They dig a hole in the bank of water bodies and thus leading to instability (Francesca and Vadim, 2006). Crayfish can also accumulate metals or toxins produced by bacteria in the water and as a result toxins can be transmitted to people consuming them (Yamamoto, 2010).

Presence and establishment of *Cherax quadricarinatus* in Pra Pong reservoir may be linked to environmental conditions that support its population. Overall water quality of Pra Pong reservoir was good and suitable for *C. quadricarinatus*. Environmental variables were DO (5.14±0.46 mg/l), pH (7.73±0.75), electrical conductivity (5.14±0.46 µS/cm), TDS (22.3±2.88 mg/l), and water temperature (33.34±0.38 °C).

Figure 2. *Cherax quadricarinatus* was captured from Pra Pong reservoir in May 2013.

Conclusion

Successful invasion of crayfish may be due to the fact that they have short life cycle and high fecundity. Crayfish also consumed all types of food sources such as small fish, freshwater shrimps, submerged plants and rice. In addition, crayfish populations have already established in the wild of Thailand and thus in the future they may pose ecological and biological impact on native resources. Further studies of potential impact of crayfish in the wild should be carried out and monitored.

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