SURVEY OF TERRESTRIAL AND AQUATIC MALACOPHAGOUS INSECTS IN SHARQUYIA GOVERNORATE EGYPT AND THE PREDATORY ACTIVITY OF *PTEROSTICHUS BARBARUS* DEJEAN

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ABSTRACT

A survey of aquatic and terrestrial malacophagous insects associated with snails was carried out during 2016-2018 in Sharquyia Governorate. Four terrestrial snails and three aquatic snails were collected. Terrestrial snails were more abundant on clover, wheat, lettuce and faba beans. Aquatic snails were abundant in rice fields. Three aquatic and three terrestrial malacophagous insect species were found associated with the above-mentioned snails. *Petrostecus barbarus*; a terrestrial arthropod; showed individual and gregarious predation on land snails under laboratory conditions. The predatory activity of this species was studied on *Monacha obstructa* snails and its eggs. The predator became more voracious in case of gregarious predation as well as on snail eggs. Gregarious predation of *Pt. barbarus* on *M. obstructa* snails increased with increasing temperatures. Results suggested the possible role of *Petrostecus barbarus* Dejean as biological control agent against harmful snails.

Key words: Malacophagous insects, biological control, molluscs, *Petrostecus barbarus,* Sharquyia Governorate, Egypt

INTRODUCTION

Snails belonging to phylum Mollusca include several distinct lineages of terrestrial gastropods and ranked the second largest phylum after Arthropods in terms of number of species described (Lydeard *et al*., 2004). Land snails constitute about six per cent of the total species on Earth (Clark and May, 2002)

In Egypt, terrestrial snails represent important economic pests and are prevalent in many Governorates infesting and causing severe damage to ornamental plants, orchard trees, vegetables and field crops (Desoky, 2018; Azzam and Abd El-Hady, 2018). All terrestrial snails cause damage to their host plants, by feeding on leaves, blooms, flowers, fruits, trunks, limbs and even on barks (Godan, 1983; Ismail *et al*., 2003). Azzam and Tawfik (2005) recorded the existence of 16 species of terrestrial malacophagous insects including four sarcophagid species of which *Wohlfartia* sp. was reported only on slugs. Two drosophilid species and two sphaerocerid were also reported. Azzam and Tawfik (2002) found that *Parasarcophaga pharaonis* could predate land snails and suggested its possible role in controlling these harmful pests.

Some of aquatic molluscs species serve as intermediate hosts of very important parasitic diseases infecting human and animals were recorded from several Governorates of Egypt Azzam and Belal (2006). Younes *et al.* (2015) evaluated the predatory capacity of *Hemianax ephippiger* nymph (Order: Odonata) as a biological control agent against the freshwater snail *Lymnaea natalensis*, the intermediate host of *Fasciola gigantica*. They found that nymphs could kill and consume all three sizes of snails.

The overuse of molluscicides against these destructive pests leads to more environmental pollution (Godan, 1983). Accordingly, the present study aims at surveying terrestrial and aquatic malacophagous insects in Sharquyia Governorate to investigate their possible role as biological control agents against terrestrial and aquatic snails.

MATERIALS AND METHODS

Study area:

Surveys were carried out in Sharquyia Governorate, Egypt during 2016-2018 by collecting terrestrial and aquatic snails and their associated malacophagous insects from four villages namely Banatf and Malames (Minya Al-Qamh District); Belbes El-Balad and Kafr Ayoub (Belbes District). Monthly samples were taken from winter and summer crops such as wheat, clover, rice and other vegetable crops.

Sampling and identification of snails and their associated insects:

Terrestrial snails were hand-collected and transferred in muslin cloth bags to the laboratory. After identification of molluscs, every species was confined in a terrarium with size suitable to the number and size of snails. Aquatic snails were collected from rice fields, using a metallic strainer (22 cm in diameter), with aluminum handle 70 – 200 cm (Azzam and Tawfik 2005). In the laboratory, snails were thoroughly washed by suitable stream of tap water and identified according to the keys of Malek (1974), Ibrahim *et al*. (1999), Godan (1983) and Nichols and Cooke (1990). After identification, each species was kept in an aquarium. In addition, snails were investigated to check for the presence of parasites. Aquatic and terrestrial malacophagous insects were collected simultaneously while collecting the snails and were identified according to Younes *et al*. (2016).

Predation and preference of malacophagous insects:

Collected insects were kept individually in plastic pots, with some the collected snails to investigate predation. Attacked and moribund snails were kept individually in glass beakers 50-250 ml according to their size, covered with perlon gauze secured with rubber bands to screen for parasitism. Snails were also dissected to check for the presence of parasites. Insect larvae emerged from the molluscs were introduced to healthy lab-bred molluscs to investigate their malacophagous activity (Shahawy *et al*., 2008).

Both individual and gregarious predation of malacophagous insects were investigated. Individual predation was carried out by placing one adult of the most voracious insect predator with ten snails at 25℃. Gregarious predation was investigated by placing 10 insects with 10 adult snails in one jar at three different temperatures 20℃, 25℃ and, 30℃. Gregarious predation of the insect predator on 10, 20, 40 snail eggs was also investigated at 25℃. Preference of the predator between the snails and its eggs was investigated by placing ten or twenty snails and its eggs in the same cage. Three replicates were used for each experiment.

Statistical analysis:

Predation rates were expressed as Mean ±SD. Data were analyzed using the non-parametric Kruskal Wallis test using Minitab software version 18. Data was considered significant at P ≤0.05.

RESULTS AND DISCUSSION

Survey of aquatic and terrestrial snails and associated malacophagous insects

Three aquatic snails were recorded from the four studied localities at Sharquyia Governorate during 2016-2018 namely *Physa acuta* (Draparnaud) (O: Mesoga stropoda, F: Physidae), *Lanistes carinatus* (Olivier) (O: Mesogastropoda, F: Pilidae) and *Bellamya unicolor* (Olivier) (O: Caenogastropoda F: Viviparidae) (Table 1). *Ph. acuta* snails were found in rice fields in all studied localities being more frequent in Malames, and Banatf while *L. carinatus* snails were recorded from Banatf only. Three aquatic malacophagous insects were found associated with the above-mentioned snails namely *Sphaerodema urinator* Duforas (O: Hemiptera F: Belasomatidae), *Hemianax ephippiger* (Burmeister) (O: Odonata, F: Aeschnidae), and *Crocothemis erythraea* (Brullé) (O: Odonata, F: Coenagrionidae). *S. urinator* was most frequent in rice fields and was associated with all snail species. *S. urinator* preferred to predate ovate-shaped shells especially *Ph. acuta*.

The abundance of *Ph. acuta* in rice fields in this study might be attributed to the presence of mosquito larvae which served as prey to the predaceous snails. Previous studies recorded the malacophagous insects *S. urinator* and *H. ephipigger* from fields and canals in Kafr El Sheikh (Hendawy *et al*., 2005) and Fayoum (Azzam and Tawfik, 2005). *H. ephipigger* was a common species in rice nurseries and fields. (El-Sherif *et al.*, 1976).

Table (1): Aquatic snails and their associated malacophagous insects collected from rice fields in Sharquyia Governorate during 2016-2018

Snail species	Frequency	Locality	Malacophagous species	Frequency
Ph. Acuta	+	Belbes El-Balad	*S. urinator*	+
Ph. Acuta	++	Kafr Ayoub		+++
B. unicolor	+	Kafr Ayoub		+++
Ph. Acuta	+++	Malames		+++
L. carinatus	+	Banatf		+++
Ph. *Acuta*	+++	Banatf		+++
Ph. Acuta	+	Kafr Ayoub	*C. erythraea*	++
Ph. acuta .	+++	Malames		++
B. unicolor	+	Banatf		+
Ph. Acuta	+++	Banatf		+++
Ph. *Acuta*	+++	Malames	*H. ephippiger*	+

(+) Low infestation (< 15 snails and malacophagous insects/ m^2).

(++) Moderate infestation (16-30 snails and malacophagous insects/m^2).

(+++) Heavy infestation (> 30 snails and malacophagous insects/m^2).

Four terrestrial snails namely *Monacha obstructa* (Pheiffer) (O: Stylommatophora, F: Helicidae), *Monacha cartusiana* (Müller), *Eobania vermiculata* (Müller) and *Succinea* sp. (O: Stylommatophora, F: Succineidae) were recorded. *M. obstructa* was the most abundant snails and was found in Belbes El-Balad, Banatf, Malames and Kafr Ayoub. *M. obstructa* was found to infest wheat (*Triticum vulgare*), colver (*Trifolium alexandrinum*), beans (*Vicia faba*), lettuce (*Lacttuca sativa*), water cress (*Eruca sativa*), cabbage (*Brassica oleracea*), garlic (*Allium sativum*), onion (*Allium cepa*). *E. vermiculata* was only found in Banatf on citrus trees (*Citrus natsudaidai*).

Succinea sp. was the least abundant snail and was only found in wet areas around citrus trees in Banatf and Kafr Ayoub (Table, 2).

Three terrestrial malacophagous insects namely *Megaselia scalaris* (Loew) (O: Diptera, F: Phoridae), *Drosophila* sp. O: Diptera,F: Drosophilidae). and *Pterostichus barbarus* Dejean. (O, Coleoptera; F: Carabidae), were found in association with the abovementioned snail species, (Table 2).

Our results indicated that *S. urinator* was the most abundant aquatic malacophagous insect and was associated with most spread snail *Ph. acuta* in rice fields. *Megaselia scalaris* and *Drosophila* sp. were the most abundant malacophagous insects and were associated with the most invasive terrestrial snail species *M. obstructa* in clover fields. No parasites were found in all collected snails from the four villages in Sharquyia Governorate.

Monacha cartusiana and *Succinea* sp. were previously reported from Sharquyia Governorate (Mahrous *et al.* 2002a) while *E. vermiculata* was recorded from El-Beheira Governorate (Eshra, 2013) and *Monacha obstructa* snails were recorded from the coastal area of the Nile Delta (Kassab and Daoud, 1964; El-Deeb *et al*., 2003). Recently *M. obstructa* and *M. cartusiana* were recorded on different plants in Menofya, Dakahlia, Giza and Arish (Azzam and Abd El-Hady, 2018). In previous surveys from some Egyptian overnorates, 17 aquatic malacophagous insects and 16 species of terrestrial malacophagous insects were recorded (Azzam and Tawfik, 2005). Four *Pterostichus* species were found in association with some adult land snails in Kafr El Sheikh Governorate (Shahawy *et al.*, 2008).

Table (2): Terrestrial snails and their associated malacophagous insects collected from different fields in Sharquyia Governorate during 2016-2018.

Snail Species	Frequency	District	Malacophagous species	Frequency	Host Plant
M. obstructa	+++	Belbis El Balad	***Pt. barbarus***	+	*Trifolium alexandrinum*
	+			ND	*Triticum vulgare*
	+			+	*Vicia faba*
	+			+	*Brassica oleracea*
	+++			+	*Eruca sativa*
	+++	Kafr Ayoub		+++	*T. alexandrinum*
	+++			+++	*Psidium guajava*
	+++	Malames		+++	*T. alexandrinum*
	+++			+++	*T. vulgare*
	+++			+	*V. faba*
	+++			+	*Lacttuca sativa*
	+++			ND	*Allium cepa*
	+++			+++	*Citrus natsudaidai*
	+++			+	*Allium sativum*
	+++			+	*A. sativum*
	+			+	*P. Guajava*
	+			++	*Zea mays*
	+++	Banatf		+	*T. alexandrinum*
	+			ND	*T. vulgare*
	+			+	*C. natsudaidai*
M. cartusiana	+++	Malames		+++	*T. alexandrinum*
E. vermiculata	+++	Banatf		+	*C. natsudaidai*
E. vermiculata	+++			+	*P. Guajava*
Succinea spp	+			+	*A. sativum*
M. obstructa	+++	Belbis El Balad	***Drosophila* sp.**	+++	*T. alexandrinum*
	+			+++	*T. vulgare*
	+			+++	*V. faba*
	+			++	*B. oleracea*
	+++			++	*E. sativa*

Cont.Table (2):

Snail Species	**Frequency**	**District**	**Malacophagous species**	**Frequency**	**Host Plant**
	+++	Kafr Ayoub		+	*T. alexandrinum*
	+++			++	*P. sativum*
	+++	Malames		+++	*T. alexandrinum*
	+++			ND	*T. vulgare*
	+++			ND	*V. faba*
	+++	Banatf		++	*T. alexandrinum*
M. obstructa	+++	Belbis El Balad	***M. scalaris***	+++	*T. alexandrinum*
	+			++	*T. vulgare*
	+++	Malames		++	*T. vulgare*
	+++	Belbis El Balad		+++	*E. sativa*
	+++	Kafr Ayoub		+++	*T. alexandrinum*
	++			+++	*P. sativum*
Succinea sp.	+			+	*P. sativum*
M. obstructa	+++	Malames		+++	*T. alexandrinum.*
	+++			++	*T. vulgare*
	+++			+++	*V. faba*
	+++			++	*L. sativa*
	++			++	*A. cepa*
	++			++	*C. natsudaidai*
	++			++	*A. sativum*
M. cartusiana	+++			++	*T. alexandrinum*
M. obstructa	+++	Banatf		+++	*T. alexandrinum*
E.vermiculata	+++			++	*C.natsudaidai*
Succinea sp.	+			++	*C. natsudaidai*

(+) Low infestation (less than 15 snails and malacophagous insects/m^2).

(++) Moderate infestation (between16-30snails and malacophagous insects/m^2).

(+++) Heavy infestation (more than 30 snails and malacophagous insects/m^2).

ND = Not Detected

Gregarious and individual predation and prey preference:

Predation experiments were carried out on *M. obstructa* snails because they were the most abundant and voracious terrestrial snails. Pilot experiments revealed that *Pt. barbarus* adults were the most predaceous of all terrestrial malacophagous insects collected. Accordingly, individual and gregarious predation and prey preference of *Pt. barbarus* adults on *M. obstructa* snails were investigated.

Gregarious predation of *Pt. barbarus* on 10 *M. obstructa* snails at different temperatures varied significantly (H=23.93; df= 2; p=0.001). Highest mean daily consumption rate (5.7±3.13) was recorded at 30°C, while minimum daily consumption rate (2.10±1.08) was recorded at 20°C (Table 3). The increase in daily consumption with the increase of tempreture observed in present study corroborates the results of **Ayre (2001)** who found a significant increase in the predation proportion of *Pterostichus madidus* (Fabricius) and *Harpalus rufipes* (Degeer) beetles on slugs as temperature increased. **Shahawy *et al*. (2008)** reported that four *Pterostichus* species were able to feed upon land snails.

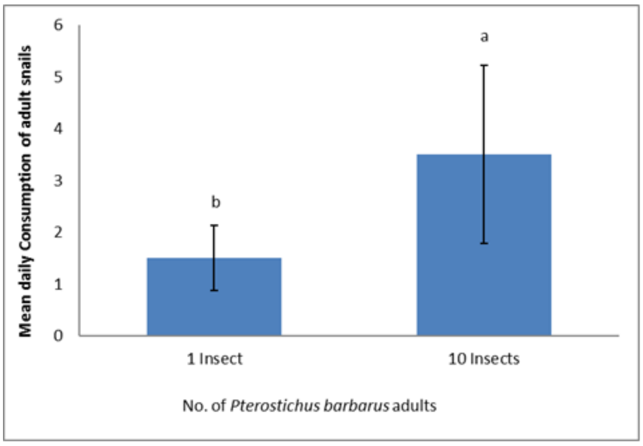
Table (3): Mean predatory activity of 10 *Pterostichus barbarus* insects on 10 *Monacha obstructa* snails at different temperatures

Temperature °C	**Daily consumption** Mean ± SD (Range)
20°C	2.10± 1.08 (1-5)
25°C	3.5± 1.72 (1-7)
30°C	5.7± 3.13 (1-9)

Individual predation of *Pt. barbarus* on 10 *M. obstructa* snails was significantly higher than gregarious predation of 10 *Pt. barbarus* on 10 *M. obstructa* snails (H= **24.85**; df=1; P = **0.000**). The mean daily consumption of 10 insects reached 3.5±1.72 while that of one insect was 1.5±0.63 (H=23.09; df=1; P=0.004) (Fig 1).

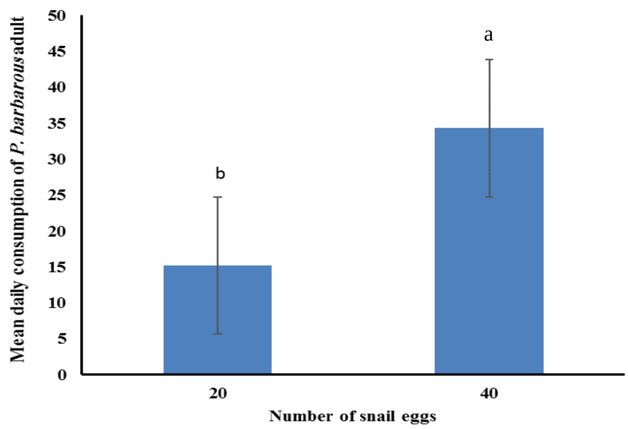
The gregarious predation of *Pt. barbarus* on snail eggs significantly increased with the increase in snail density (H=41.78; df=1; p=0.005). The daily consumption of the insects on 40 snail eggs reached 34.3±6.01 while it reached 15.21±6.18 on 20 eggs (Fig 2). Similar results were obtained by Oberholzer and Frank (2003) who found that a range of 1-10 eggs of *Deroceras reticulatum* were destroyed in 24 h by one *Poecilus cupreus* maintained at temperature cycle of 15˚C for 12h and 10˚C for 12h.

The prey preference of *Pt. barbarus* was investigated between the adult snails and snail eggs. *Pt. barbarus* significantly preferred snail eggs (H=21.78; df=1; p=0.00). The daily consumption rate of the insects simultaneously fed on 10 snail eggs was 9.47±1.07 while it reached 0.23±0.43 on 10 adult snails (Fig 3). Similarly, the daily consumption rate of *Pt. barbarus* on 20 snail eggs was significantly higher than the daily consumption on 20 adult snails (H=26.00; df=1; p=0.00). *Pt. barbarus* daily consumed 19.73±5.15 eggs while it consumed 1.63±0.76 adult snails (Fig 3). Juvenile stages were found to be more vulnerable for predator attacking, while the adults of snails were able to protect themselves either by disappearing inside the hard shell or by releasing extensive mucus (Sallam and El-Wakeil, 2012).



a:SD of consumption 10 insects to 10 snails; b: SD of consumption one insects to 10 snails

Fig (1): Daily consumption of *Pterostichus barbarus* on *Monacha obstructa* adult snails at 25 °C and 75 % RH.



a:SD of consumption 40 snail eggs, b:SD consumption 20 snail eggs

Fig (2): Effect of snail eggs density on the daily consumption of *Pterostichus barbarus* at 25°C and 75% RH

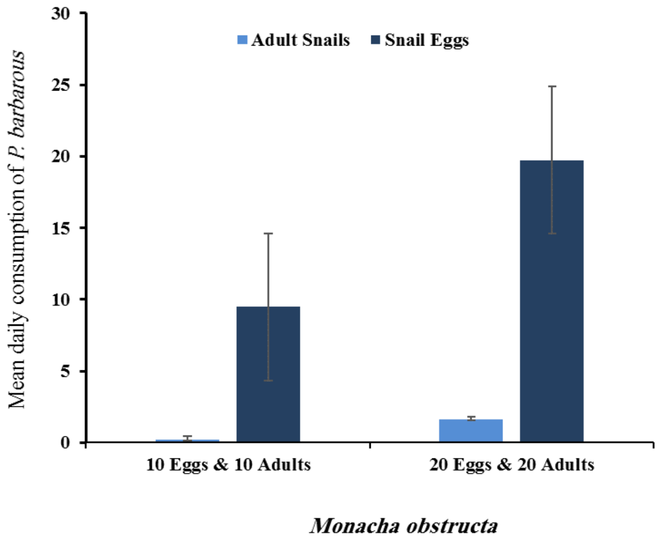


Fig (3): Prey preference of *Pterostichus barbarus* simultaneously fed on *Monacha obstructa* adults and eggs at 25°C and 75% RH

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دراسة استقصائية للحشرات المفترسة للقواقع الأرضية والمائية في محافظة الشرقية والكفاءة الافتراسية للمفترس *Pterostichus barbarus* Dejean

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المستخلص

تم عمل حصر للحشرات الأرضية والمائية التي تتغذى على القواقع الأرضية والمائية في أربع قرى في محافظة الشرقية. تم رصد أربعة أنواع من القواقع الأرضية وثلاثة أنواع من القواقع المائية. كما تم رصد ثلاثة أنواع من الحشرات المفترسة للقواقع الارضية وثلاثة أنواع من المفترسات على القواقع المائية.

وجدت هذه الحشرات مصاحبة للقواقع التي تصيب العديد من النباتات الزراعية مثل القمح والبرسيم والفول والأرز والبصل والثوم والجرجير والكرنب والخس والبرتقال والجوافة وغيرها. أثبتت التجارب المعملية الكفاءة الافتراسية لخنفساء *Pterostichus barbarus* للقواقع الأرضية سواء في حالة الافتراس الفردي أو الجماعي. أظهرت النتائج أن الافتراس الجماعي أفضل بكثير من الافتراس الفردي وفضلت الحشرة افتراس البيض عن القواقع. تلقي هذه الدراسة الضوء على الدور المحتمل لحشرة *Pterostichus barbarus* في مجال المكافحة البيولوجية للقواقع مما يدفع للحد من استخدام المبيدات الحشرية الضارة بالبيئة وصحة الإنسان والحيوان.

الكلمات المفتاحية: الحشرات المفترسة – المكافحة البيولوجية – القواقع – محافظة الشرقية – مصر *Pterostichus barbarus* **Dejean**