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Original Article

Survey and population dynamics of land snails at Sharkia Governorate, Egypt

Levantamento e dinâmica populacional de caracóis terrestres na província de Sharkia, Egito

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Abstract

Land snails are a destructive agricultural pest in economic crops, but the populations for that pest are highly influenced by temperature and humidity, therefore climatic changes affected their behavior, distribution and population dynamics, for these reasons researchers should follow up on the changes in their behavior, distribution, and population dynamics.

In this study, a survey study was conducted to define land snail species existing at Sharkia Governorate, Egypt, from January 2019 to March 2022 in horticultural, vegetable, and field crops and study the population dynamics for the dominant land snail species. Results showed that there are six species of land snails, these species were, *Monacha cartusiana*, *Succinea putris*, *Eobania vermiculata*, *Theba pisana*, *Helicella vestalis*, and *Cochlicella acuta*. The population dynamics of two prevalent land snail species (*M. cartusiana* and *S. putris*), were conducted during two successive growing seasons, the Egyptian clover harbored the highest number of *M. cartusiana* followed by wheat, while the onion was the lowest one during the study period. In the same trends, the land snail *S. putris* recorded the highest numbers during the growing season of the Egyptian clover crop. Finally, it is concluded that the land snail *M. cartusiana* considered the first grade of infestation existed everywhere at Sharkia Governorate, and the population density of the land snail is increase gradually after winter till reach the maximum density in spring.

Keywords: field crops, horticultural crops, land snails, survey, population dynamics.

Resumo

Os caracóis terrestres são pragas agrícolas destrutivas em cultivos econômicos, todavia, as populações dessa praga são altamente influenciadas pela temperatura e umidade, portanto as mudanças climáticas afetam seu comportamento, distribuição e dinâmica populacional, e, por essas razões, os pesquisadores devem acompanhar as mudanças em seu comportamento, distribuição e dinâmica populacional.

O presente trabalho foi realizado para definir as espécies de caracóis terrestres existentes na província de Sharkia, no Egito, de janeiro de 2019 a março de 2022 em culturas hortícolas, vegetais e de campo, e estudar a dinâmica populacional das espécies dominantes de caracóis terrestres. Os resultados mostraram que existem seis espécies de caracóis terrestres, essas espécies foram *Monacha cartusiana*, *Succinea putris*, *Eobania vermiculata*, *Theba pisana*, *Helicella vestalis* e *Cochlicella acuta*. A dinâmica populacional de duas espécies predominantes de caracóis terrestres (*M. cartusiana* e *S. putris*), foi conduzida durante duas safras sucessivas, o trevo egípcio abrigou o maior número de *M. cartusiana* seguido pelo trigo, enquanto a cebola foi o menor durante o período de estudo. Seguindo as mesmas tendências, o caracol terrestre *S. putris* registrou os números mais altos durante a estação de crescimento da cultura do trevo egípcio. Finalmente, conclui-se que o caracol terrestre *M. cartusiana*, considerado o primeiro grau de infestação, está presente em toda a província de Sharkia, e a densidade populacional do caracol terrestre aumenta gradualmente após o inverno até atingir a densidade máxima na primavera.

Palavras-chave: culturas de campo, culturas hortícolas, caracóis terrestres, enquete, dinâmica populacional.

1. Introduction

The phylum Mollusca is divided into eight classes (Aplacophora, Monoplacophora, Polyplacophora, Scaphopoda, Bivalvia, Gastropoda, and Cephalopoda) but the Gastropoda is the largest class (70.000 species) including snails and slugs which are present on every continent (Haszprunar, 2020; Pyron and Brown, 2015).

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Terrestrial gastropods including land snails inhabit a wide range of environments from arid to Mediterranean regions (Schweizer et al., 2019) as well as Egypt (Morsy et al., 2021). It is recorded in many Governorates, Dakahli (Mortada et al., 2012), Minufya (Asran et al., 2011), Kafr ElSheikh (Heiba et al., 2018), and Sharkia (Abed, 2017).

Land snails are serious pests causing damage to the agriculture sector around the world (Barker, 2002). Land snails had been recorded to infest many crops in Egypt (Heiba et al., 2018) and caused damage to field crops, cereals, ornamental, seeds of oil plants, medicinal fruits (mango, strawberry, citrus, peach and palm trees), and vegetables (carrot, lettuce and cabbage) (El-Okda, 1984; El-Deeb et al., 1999; Ismail et al., 2003; Shahawy et al., 2008; Ibrahim et al., 2017). Studying the survey and the population dynamic of land snails as agricultural pests is essential for designing effective pest control strategies to reduce the financial losses to economic field crops, vegetables, and fruits.

This study aims to survey the species of snails that infest many varieties of crops exist in Sharkia Governorate in addition to studying the population dynamics of two terrestrial snails: *Monacha cartusiana* and *Succinea putris* on the economic filed crop: Egyptian clover, wheat, and onion through at two growing seasons at Sharkia Governorate, Egypt.

2. Materials and Methods

2.1. Survey studies

A survey study was carried out in three districts (Hehia, Belbies, and Meniet El-Kammh) belonging to Sharkia Governorate, Egypt. At each district three villages were chosen randomly, these localities were (Al-Awasga, Sopeh and Kafr Abou Hatab) at Hehia, (Sekm farmer, Basateen Barakat and Basateen El-esmaaleia) at Belbies, and (Banadf, Al-Mohmmadia and Malames) at Meniet El-Kammh. Sampling took place at each site from January 2019 to March 2022.

The survey was conducted on many host plant species including:

a. Field crops: as Egyptian clover, (*Trifolium alexandrinum*), wheat (*Triticum aestivum*), broad bean (*Vicia faba*), onion (*Allium cepa*), garlic (*Alium sativum*) and Elephant grass (*pennisetum purpuremum schumach*);
b. Vegetable crops: cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa*), parsley (*Petroselinum crispum*), dill (*Anethum graveolens*), coriander (*Coriandrum sativum*), chard (*Beta vulgaris subsp.*) and mallow (*Malva parviflora*);
c. Horticultural crops: such as navel orange (*Citrus sinensis*), lemon (*Citrus limon*), guava (*Psidium guajava*), mango (*Mangifera indica*), and tangerines (*Citruc aurantium*) and fennel (*Foeniculum vulgare*).

Samples were collected from different crops by using quadrate sample size 50 × 50 cm (Staikou and Lazaridou-Dimitriadou, 1990; Abd-Elhaleim et al., 2022). The snail samples transferred through a highly ventilated plastic box containing the same host plant. The snails were identified using a key given by (Godan, 1983).

2.2. Population dynamics

Population dynamics of two prevalent species (*M. cartusiana* and *S. putris*) were recorded on three types of crops (Egyptian clover, wheat, and onion) at Awasga, village, Hehia districts during two successive growing seasons (2019/2020) and (2020/2021).

In the early morning, by using the quadrate method size 50 × 50 cm^2 all live snails were counted either on soil or plant and left in their place (Baker, 1988). Ten random quadrat samples were taken biweekly at each crop during the growing season.

2.3. Data analysis

The biweekly average temperature degree and relative humidity of the locations were obtained from Central Climate Laboratory, Agricultural Research Center, the correlations between temperature and relative humidity as climatic factors and population dynamics of the two land snails (*M. cartusiana* and *S. putris*) were interpreted for statistical analysis according to CoStat (2005).

3. Results

3.1. Survey studies of land snails at certain districts in Sharkia Governorate

The survey was carried out on land snails infesting different crops during the growing season at nine villages representing three districts in Sharkia Governorate. Results tabulated in Table 1 revealed that six species of land snails belonging to different families of order: stylommatophora were observed on various crops. Those families are: Hygromiidae (*Monacha cartusiana*), Succineidae (*Succinea putris*), and Helicidae (*Eobania vermiculata*), Helicidae (*Theba pisana*), Geomitridae (*Helicella vestalis*), and Geomitridae (*Cochlicella acuta*).

The identified species varied in their incidence and level of infestation according to locality and host crop. It was obvious that *M. cartusiana* snail has a superior incidence compared with the other species since it was recorded in all surveyed localities. Moreover, many of the examined plants were liable to be infested with this snail followed by *E. vermiculate*, *T. pisana*, and S. putris while *H. vestalis*, and *C. acuta* were observed in one site on many hosts. The listed hosts can be classified into three categories according to the degree of infestation. These categories were heavy, moderate, and light infestation. The majority of examined crops were found with heavy or moderate infestation with previously snail species especially Egyptian clover, Wheat, Lettuce, Cabbage, Broad bean, Orange, Mango, Tangerines, Fennel, Dill, parsley, Coriander, Chard, Mallow and Elephant grass. On the other hand, lemon, guava, onion, and garlic plants were the least infested hosts.

3.2. Population dynamics

3.2.1. Population dynamics of M. cartusiana on some crops in Sharkia Governorate

Seasonal population dynamics of *M. cartusiana* snails were studied on certain crops (Egyptian clover, wheat,

Table 1. Survey of land snails and level of infestation of different crops in Sharkia Governorate during two growing seasons (2019/2020) and (2020/2021).

Districts	Villages	Species	Host plants
Hehia	Al- awasga	*M. cartusiana*	Egyptian clover (+++) wheat (++) lettuce (+++) cabbage (+++) onion (+) broad bean (++) garlic (+)
		S. putris	Egyptian clover (+++)
	Kafr Abou- Hatab	*M. cartusiana*	Egyptian clover (+++) wheat (++) lettuce (+++) cabbage (+++) dill (++) parsley (++) coriander (++) chard (++)
		S. putris	Egyptian clover (++) cabbage (+)
	Sobaih	*M. cartusiana*	Egyptian clover (+++) wheat (++) lettuce (+++) cabbage (++)
Belbeis	Sekem farm	*E. vermiculata*	mallow, (++)
		M. cartusiana	mallow, (++) wheat (++) elephant grass (++)
		H. vestalis	fennel (++) wheat (+)
		C. acuta	fennel (+++) mallow, (++) elephant grass (++)
	Barakat orchards	*E. vermiculata*	orange (+++) mango (++) tangerines (++`)
		M. cartusiana	orange (++) mango (+) tangerines (+)
		T. pisana	orange (+++) mango (++)
	Basateen El-Ismaaleia	*M. cartusiana*	Egyptian clover (++) wheat (+) lettuce (+) cabbage (+) mango (+) lemon trees (+), guava trees (+)
Meniet El-kamh	Al-Mohamadia	*M. cartusiana*	wheat (+++) Egyptian clover (+++) broad bean (+) cabbage (+++)
		E. vermiculata	orange (+++) cabbage (+++) tangerines (+++)
		T. pisana	orange (+++) mango (+++) tangerines (+++) wheat (+++) Egyptian clover (+++) broad bean (+++) cabbage (+++)
	Banadf	*M. cartusiana*	Egyptian clover (+ + +), Brood bean (++), wheat (+), cabbage (++)
		E. vermiculata	navel orange (+ + +)
		S. putris	Egyptian clover (+ +)
	Malames	*M. cartusiana*	Egyptian clover (+) lettuce (+)
		E. vermiculata	navel orange (+ +). brood bean (+) cabbage (+) Egyptian clover (+) lettuce (++)
		T. pisana	navel orange (++) brood bean (+) Egyptian clover (+) lettuce (++)

(+) = Low infestation (less than 15 snails 0.25 cm^2); (++) = Moderate infestation (between 15-30 snails 0.25 cm^2); (+++) = Heavy infestation (more than 30 snails 0.25 cm^2).

and onion) in Hehia district, El-Awasga village), Sharkia Governorate during the two growing successive seasons (2019/2020) and (2020/2021). Data in Table 2 showed that the initial infestation of *M. cartusiana* appeared at the beginning of November on Egyptian clover with relatively low population densities of (4.2 and 3.4) snails per quadrat sample size of (50 × 50 cm) in the growing seasons (2019/2020 and 2020/2021), respectively. On the other hand, the initial infestation in wheat appeared at the beginning of February with relatively low population densities of (2.6 and 1.6) snails per quadrat sample size of (50 × 50 cm) in the growing seasons (2019/2020 and 2020/2021), respectively.

On the other hand, the initial infestation of onion appeared at the beginning of March with relatively low population densities of (8.8 and 10.6) snails per quadrat sample size of (50 × 50 cm) in the growing seasons (2019/2020 and 2020/2021), respectively. The high census rates for *M. cartusiana* snails were found at mid of March (42.6 and 46.8) and (16.6 and 13.6) snails per quadrat sample size of (50 × 50 cm) in the growing seasons (2019-2020 and 2020-2021), for Egyptian clover and wheat, respectively.

Regarding onion, infestation reached its sparse number (1.2 and 5) during May month, whilst the high infestation was recorded in mid of March (11.2 and 13) snails per quadrat samples, respectively.

Generally, it was noticed that Egyptian clover harbored the highest number of snails with which the total number recorded (at 262.8 and 302.8) for two successive seasons (2019/2020 and 2020/2021), followed by wheat (57.2 and 50) while the onion is the lowest one which gave (31.8 and 43.4), respectively.

Table 2. Population dynamics of *M. cartusiana* and *S. putris* snails at Hehia district, Sharkia Governorate during two growing seasons (2019/2020) and (2020/2021).

Date of inspection	Average number of snails sample/0.25m2								Temp. (C)		R.H.%	
	M. cartusiana						*S. putris*					
	Egyptian clover		Wheat		Onion		Egyptian clover					
	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21
Sep.	-	-	-	-	-	-	-	-	26.13	27.1	54.34	53.26
	-	-	-	-	-	-	-	-	25.98	26.54	53.98	59.78
Oct.	0	0	0	0	0	0	0	0	26.71	27.49	54.76	56.29
	0	0	0	0	0	0	0	0	24.22	25.50	62.99	59.23
Nov.	4.2	3.4	0	0	0	0	0	0	22.53	22.49	63.99	58.49
	9.4	6.2	0	0	0	0	0.2	0.4	19.97	18.37	54.20	65.49
Dec.	10.2	8	0	0	0	0	0.8	1.4	15.84	16.91	65.51	52.56
	10.8	13.8	0	0	0	0	1.2	2	13.77	16.13	66.23	70.59
Jan.	11.8	16.2	0	0	0	0	2	3.4	12.14	17.08	68.77	65.91
	13	24.6	0	0	0	0	2.2	5.8	12.60	12.90	72.11	61.95
Feb.	21.2	29	2.6	1.6	0	0	9.6	7.2	12.89	16.22	66.46	55.09
	28.6	35.6	6.6	2.8	0	0	10.2	10	13.92	12.87	71.37	70.32
Mar.	40.4	39.2	13.4	10.4	8.8	10.6	11.2	12.8	16.46	15.36	60.16	66.27
	42.6	46.8	16.6	13.6	11.2	13	12.6	18.2	16.68	16.09	63.34	63.35
Apr.	38.6	37.6	12	11.4	7.6	9	20	21.4	18.37	17.51	58.89	56.45
	19.2	23.8	6	10.2	3	5.8	20.6	22	20.42	23.41	60.54	47.25
May.	4.8	14.6	-	-	1.2	5	12	11	21.06	28.26	61.07	37.01
	2.2	3.4	-	-	-	-	7.2	7	25.36	26.92	51.85	42.59
Total	262.8	302.8	57.2	50	31.8	43.4	109.8	122.6				
Mean	16.43	18.92	4.1	3.57	2.12	2.8	6.86	7.66				

R.H.%: Relative humidity.

3.2.2. Population dynamics of S. putris on Egyptian clover crop in Sharkia Governorate

Seasonal population dynamics of *S. putris* snails on Egyptian clover at Al-awasga village, Hehia district at Sharkia Governorate during the two growing successive seasons (2019/2020) and (2020/2021).

Data in Table 2 showed that initial infestation of *S. putris* appeared at (or in) the beginning of mid-November on Egyptian clover with low population densities of 0.2 and 0.4 snails per quadrat sample size (50 × 50 cm) in the growing season (2019/2020) and (2020/2021), respectively. Regarding the population behavior of S. putris after the initial infestation, it was clear that the number of snails slightly increased to reach its peak, 20.6 and 22 snails per quadrat sample size (50 × 50 cm) at (in) mid-April for growing seasons (2019/2020) and (2020/2021), respectively. Generally, in the growing seasons of Egyptian clover, it could be noted that the average total population of *S. putris* snails could reach up to (109.8 and 122.6) snails per quadrat size (50 × 50 cm) in the growing seasons (2019/2020) and (2020/2021), respectively.

3.3. Correlation between temperature, relative humidity, and population dynamics.

The correlation for some climatic factors with population density of *M. cartusiana* and *S. putris* was presented in Tables 3 and 4, which revealed that, temperature and relative humidity showed variable effects on population density. On all crops, there is an insignificant negative correlation between population density and relative humidity for two snails, except the population of *M. cartusiana* on Egyptian clover which showed a highly significant negative correlation. In respect to temperature, all crops showed an insignificant negative correlation on two land snails except the population of *M. cartusiana* on Egyptian clover which showed an insignificant positive correlation.

4. Discussion

Our results showed that about six species of land snails infested many crops in Sharkia Governorate; these species

Table 3. The correlation between relative humidity and population density of *M. cartusiana* and *S. putris* snails during two growing seasons (2019/2020) and (2020/2021).

Snail species	Host plant	Relative humidity (%)					
		2019/2020			2019/2020		
		r	b	P-value	r	b	P-value
M. cartusiana	Egyptian clover	-0.487	-0.161	0.055^{ns}	-0.645	-0.221	0.006**
	Wheat	-0.117	-0.091	0.689^{ns}	-0.141	-0.121	0.629^{ns}
	Onion	-0.039	-0.046	0.889^{ns}	-0.069	-0.067	0.805^{ns}
S. putris	Egyptian clover	-0.081	-0.054	0.763^{ns}	-0.137	-0.094	0.612^{ns}

P ≤ 0.05, r: Simple correlation; b: Liner regression coefficient; $^{n.s.}$: non-significant; **highly significant.

Table 4. The correlation between temperature and population density of *M. cartusiana* and *S. putris* snails during two growing seasons (2019/2020) and (2020/2021).

Snail species	Host plant	Temperature ©					
		2019/2020			2019/2020		
		r	b	P-value	r	b	P-value
M. cartusiana	Egyptian clover	0.184	0.075	0.494ns	0.292	0.183	0.271^{ns}
	Wheat	-0.259	-0.137	0.612ns	-0.154	-0.199	0.598^{ns}
	Onion	-0.111	-0.361	0.350ns	-0.1232	-0.240	0.661^{ns}
S. putris	Egyptian clover	-0.111	-0.092	0.680ns	-0.218	-0.274	0.417^{ns}

P ≤ 0.05, r: Simple correlation; b: Liner regression coefficient; ^{ns}: non-significant.

were (*M. cartusiana*, *S. putris, E. vermiculata*, *T. pisana*, *H. vestalis*, and *C. acuta*). These results agree with the foregoing results, that the land snails, were found at different Governorates, for instances, *E. vermiculate*, *T. pisana*, *H. vestalis*, *M. obstructa*, *C. acuta*, *Rumina decollate* and *Oxychilus sp.* were found in Alexandria and Beheira Governorates (El-Okda, 1980). In Sharkia Governorate five species of land snails are found in different localities (Mahrous et al., 2002), these species were *M. cartusiana*, *C. acuta*, *H. vestalis*, *E. vermiculata*, and *Succinea sp.* Ismail et al. (2011) found that *M. cartusiana* and *S. putris* snails were found at Hehia and Meniet El-Kamh where *M. cartusiana* was found with higher density than *S. putris* on the crops and weeds. Many of the examined crops were found with heavy infestation with *M. cartusiana* while infestation with *S. putris* was light to moderate. Rady et al. (2014) found that five species of land snails infesting different crops in Ismailia and Sharkia Governorates, these species were *M. cartusiana*, *C. acuta*, *S. putris*, *D. leave*, and *D. reticulatum*. The same trend was found by Abed (2017) in Sharkia Governorate, he revealed that four species of gastropods belonging to three families of order: Stylommatophora existed in Sharkia governorate. These families are Family: Hygromiidae represented by two snails *M. cartusiana* and *M. cantiana*, Family: Succinidae represented by the snail *S. putris*, and Family: Agriolimacidae represented by the slug *Deroceras laeve*. *M. cartusiana* snails have superior snail incidence compared to other species as it was recorded in all surveyed localities. Some field and vegetable crops indicated that Egyptian clover highest numbers followed by cabbage, while onion was the lowest one in this respect (Kadry et al., 2018). Finally, Abd-Elhaleim et al. (2022) reported that the incidence and level of infestation of terrestrial snails varied according to the locality where *E. vermiculata* were the prevalent land snail species in Beheira, while in Giza *Monacha obstructa* infested the majority of the examined fruit trees.

The population density of *M. cartusiana* increased during March as compared to the other months while concerning *S. putris* snails, they could reach the maximum peak in April, and also it was obvious that Egyptian clover harbored both the two snail species, but wheat was in the second rank for *M. cartusiana*. These are in line with Hegab et al. (1999) who reported that the Egyptian clover harbored the highest numbers of *M. cartusiana* followed by wheat, while broad bean showed the lowest numbers.

M. cartusiana appeared at the beginning of November on Egyptian clover low population densities but the highest numbers of snails were found at mid of March. These results are consistent with previous studies that spring months (March, April, and May) inhabited an increase in population density for *M. cartusiana*, while it was low to moderate during the winter and autumn months (Mahrous et al., 2002; Lokma, 2007; Ismail et al., 2011; Abed, 2017). Finally, the lowest population density was recorded in August till winter and then it began to gradually increase until it reached its highest value in the spring season, affected by climate factors (Abd-Elhaleim et al., 2022).

The correlation between climatic factors (temperature and relative humidity) and population density of land snails (*M. cartusiana* and *S. putris*) were inconstant relationship (Abed, 2017). Also, Abd-Elhaleim et al. (2022) reported that the incidence and infestation level of terrestrial snails varied according to climatic factors.

5. Conclusions

The land snail *M. cartusiana* is considered the first grade of infestation and was recorded in all surveyed localities at Sharkia Governorate. Moreover, most of the examined plants were liable to be infested with that snail followed by *E. vermiculate*, *T. pisana* and *S. putris* while *H. vestalis*, *C. acuta* occurred only one time at one site in Sharkia Governorate. The population density of land snails increases gradually after winter reaching their maximum density during spring. Hence, this study gave sufficient data for management workers of land snails which helped them to choose the right time to intervene in integrated control operations.

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