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Research Article

Survey and Seasonal Population Dynamics of Terrestrial Snails Infesting Some Fruit Trees and Ornamental Plants at Gharbia Governorate

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Abstract:

Terrestrial gastropods are one of the most dangerous pests attacking a variety of plants, including field crops, vegetables, fruit trees and ornamental plants. Survey and population dynamics were carried out on land snails and slugs infesting certain fruit trees and ornamental plants in nine localities (villages) representing three districts (counties) at Gharbia governorate during their activity period from January to April in 2021/2022 and 2022/2023. Four land snail species, and one land slug species were recorded. The snails were, the brown garden (chocolate banded) snail, *Eobania vermiculata* (Müller), the glassy clover snail, *Monacha cartusiana* (Müller), the white garden snail, *Theba pisana* (Müller), the amber snail *Succinea putris* (Linnaeus) ,besides the grey garden slug, *Deroceras reticulatum* (Müller). *M. cartusiana* and *E. vermiculata* snails were the predominant species, since they were found on almost all hosts and localities with moderate or high levels of infestation .While *T. pisana* snail showed less occurrence with moderate to high infestation levels in the three localities of Zefta district. However, *S. putris* and *D. reticulatum* were found with limited distribution in one or two localities of Al-Santa district with low level of infestation. The population dynamics of *E.vermiculata*, *M.cartusiana*, and *T.pisana* snails were studied on navel orange trees in Kafr Shobra Al-Yaman village, Zefta district, Gharbia governorate over two growing seasons (2021/2022 and 2022/2023). The active snails first appeared in November, with slight increases in numbers during the winter months of December and January. A noticable population increase occurred in February, peaking in April, followed by a decline in May. In general, the seasonal abundance of *E. vermiculata*, *M. cartusiana* and *T. pisana* snails increased during spring compared to winter and autumn, while snails aestivate during summer months.

1. Introduction

Terrestrial gastropods have increased in their importance value and become serious pests because they damage a wide range of plants, including field crops, ornamental plants , vegetables and fruit trees worldwide (Barker, 2002). They attack plant leaves, tubers, and roots. Due to increasingly dense and rapid transportation and traffic, these pests are considerably more devastating now than before since there are no restrictions on their mobility not only from one country to another but even from one area to another. Snail intra- field movements release an unpleasant odor that discourages and even stops animals and people from consuming these infested plants. (El-Okda, 1984; Ismail et al., 2017; Bayoumi, 2018; Ezzat, 2021 and Abd-Elhaleim et al., 2022). These molluscs cause damage by feeding and contamination of their bodies, feces, or slime, which reduces the quality of the product and results in decreasing the cash values (Iglesias et al., 2003). Furthermore, it is known that a large number of land snails act as intermediate hosts for nematode and platyhelminth parasites that affect humans and animals (Grewal et al., 2003 and Rashed, 2008). Additionally, they serve as carriers of several plant diseases. On the other hand, it was noted that using molluscicides to manage gastropod pests was relatively expensive. Due to the development of efficient management methods, the significance of terrestrial snails is generally becoming more apparent as the impact of insect pests declines (Barker, 2002).

Problems caused by gastropod pests on agricultural crops were reported in several countries around the world such as China (Chen, 1994), Australia (Baker, 1989), Spain (Castielleio et al., 1996) and Switzerland (Baur and Baur, 1993). It was known that land gastropod pests were mainly found in the northern Egyptian governorates of the Nile Delta, including Beheira and, Alexandria until the 1980s. They currently infest vegetable crops, fruit trees and ornamental plants, in most Delta governorates) El-Deeb et al. 1996, Mahrous et al. 2002; Rady et al., 2014; and Mohamed, 2015). In addition, snail populations can increase mainly because new introduced snails lack their native natural enemies (Godan, 1983).

The objective of this work was to study the occurrence of terrestrial gastropods on major fruit trees in each of three districts at Gharbia governorate and the seasonal population dynamics of the three most predominant land snails *E. vermiculata*, *M.cartusiana* and *T. pisana* on certain fruit trees.

2. Materials and Methods

2.1. Survey of terrestrial molluscs infesting some fruit trees and ornamental plants at Gharbia governorate

The study was undertaken during the period from Janruary 2022 to April 2023 on certain fruit trees namely, navel orange, (*Citrus sinensis* L.), guava (*Psidium guajava* L.), mango, (*Mangifera indica* L.), and ornamental plants such as yellow areca palm, (*Dypsis lutescens* Wendl.), moringa trees, (*Moringa oleifera* Lamarck), white vasaka (*Adhatoda vasica* Linnaeus), and croton (*Codiaeum variegatum Linnaeus*) at three districts (counties): Zefta, Al-Santa, and Kafr Al-Zayat which belong to Gharbia governorate (30.8754ºN,31.0335ºE). Three localities (villages) were selected as representatives of each district. These villages were Eizbat Almalika, Mit Hawai , and Mit Yazid (Al-Santa); El- Mansouria, Mansheat Soliman, and Kafr El-Baja (Kafr Al- Zayat) and Shubra Al-Yaman, Kafr Shubra Al-Yaman and Sinbat (Zefta).

A survey was undertaken on ten trees that were randomly selected from fruits and ornamental plants. Quadrate sampling method was employed, each quadrate measuring 25 by 25 cm^2 (Staikou and Lazaridou, 1990). Snails found on soil surface in the quadrate and on one meter of the tree trunk near soil were counted (Gabr et al., 2023). Levels of infestation were categorized according to (Ismail, 1997) as follows: light infestation (less than 15 snail/sample), moderate infestation (16–30 snails/sample) and high infestation (more than 30 snails/sample).

Samples were taken early in the morning and the collected land snails and slugs were transported to laboratory for identification based on the external features of shell and body according to Godan (1983) and Ali and Ramdane (2020).

2.2. Population dynamics of *Eobania vermiculata, Theba pisana* and *Monacha cartusiana* snails on navel orange trees

The population dynamics of *E. vermiculata, M. cartusiana* and *T. pisana* snails infesting navel orange trees were studied during two successive growing seasons (2021/2022 and 2022/2023) at Kafr Shubra Al-Yaman village, Zefta distrct, Gharbia governorate. In this regard, an area of about one feddan (4200m^2) cultivated with navel orange trees infested with *E. vermiculata, M. cartusiana* and *T. pisana* snails was selected for this study. The population dynamics of snails were monitored monthly during period of snail activity which occurred from November to May of each growing season utilizing quadrate sampling method according to Staikou and Lazaridou (1990) and Gabr et al. (2023) as described before. Four rows (each containing 8 trees) were selected in the designated area. One sample was randomly taken from one tree in each row during the experimentation period. Sampling was undertaken in the early morning before sunrise in absence of rain. Snails found on tree and on soil surface in the quadrate were counted and returned to their initial original places (Baker, 1988). Weather data, temperature and relative humidity during the study period were obtained from the Meteorological Station of Tanta district, Gharbia governorate. Simple correlation coefficient values between snail populations and temperature and relative humidity were calculated using SPSS program according to Costat (2005).

3. Results and Discussion

3.1. Survey of terrestrial molluscs infesting some fruit trees and ornamental plants at Gharbia governorate

A preminary survey was conducted on gastropod fauna infesting some fruit trees and ornamental plants in nine villages representing three districts at Gharbia governorate during the period from January to April, 2022 and 2023. Results showed that four snail specie and one slug species were determined belonging to different families of order: Stylommatophora. These species were: the glassy clover snail, *Monacha cartusiana* (Muller) family: Hygromiidae, the brown garden (chocolate-banded) snail, *Eobania vermiculata* (Muller) family: Helicidae, the white garden snail, *Theba pisana* (Muller)) family: Helicidae, the amber succineid snail *Succinea putris* Linnaeus, family: Succineidae, and the grey garden slug, *Derocer-as.reticulatum* (Muller), family: Agriolimacidae .

The occurrence and level of infestation of the identified terrestrial gastropod species differed according to snail species, host plant and locality (Table 1). In this respect, on fruit trees (navel orange, guava and mango) snails of *M. cartusiana* and *E. vermiculata* were more frequently encountered. The first species was found in all nine tested localities, while the second one was detected in eight localities. These two species were counted with high or moderate levels of infestation on navel orange, whereas they were found with moderate or low levels on guava and mango. On the other hand, *T.pisana* snail had a less widespread distribution. It was detected in the three localities of Zefta district with high infestation in Shubra Al-Yaman village and moderate numbers in the other two villages. However *S. putris* snail was found with limited occurrence, since it was counted in one locality (Eizbat Almalika, Al-Santa district) with low infestation on fruit trees. It was noticed that three land snail species were determined on all fruit trees in Zefta district compared to two snail species in all other surveyed localities of Gharbia governorate. Moreover the slug *D. reticulatum* was not detected on fruit trees.

Regarding the occurrence and level of infestation of the identified terrestrial gastropod species on ornamental plants, it was found that two snail species *(E. vermiculata and M. cartusiana*) as well as one slug species *(D. reticulatum*) were recorded with varying distribution and population density. *E. vermiculata* followed by *M. cartusiana* were the predominant species, as they were occurred on almost all ornamental hosts in the nine surveyed localities with variable numbers , whereas *D. reticulatum* was determined in two localities i.e., Mit Yazid (Al-Santa district) and Kafr Shubra Al-Yaman (Zefta district) with low level of infestation**.** A relatively higher numbers of the surveyed gastropods were counted on vasaka followed by moringa compared to yellow areca palm and croton. The limited incidence of snails or slugs on the ornamental plant croton may be attributed to its cultivation in Al-Santa district only.

Before discussing the foregoing results, it is necessary to mention that El-Okda (1981), reported that the active dispersal capabilities of *M. cartusiana* may be due to a relatively higher environmental tolerance, fecundity and adaptability to new habitats. Moreover, The scale given by Ismail (1997) to estimate population size of land gastropods on host plants was proposed to differentiate infestation levels as: low (>15 nails/ sample), moderate (16-30 snails / sample) and high (< 30 snails / sample). However, Ibrahim et al. (2017) indicated that the economic damage threshold of *M. cartusiana* on strawberry plants ranged 2-2.5 snail/plant while economic injury level ranged 3-7.5 snail/ plant.

Similar results were reported by many researchers who surveyed land molluscs on these plants, Ismail et al. (2011); Desoky et al. (2015); Mohamed (2015); Abdel kader (2016); Mohamed (2017); Gazzy, et al. (2018) Abd-El-Haleem et al. (2019); Gazzy et al. (2019); Rady et al. (2019); Ibrahim et al. (2021); Abd-Elhaleim et al. (2022); Bayoumi et al. (2023); El-Kady (2023); Gabr et al. (2023), and Bayoumi (2024).

Table 1. Occurrence and level of infestation of land gastropod species infesting some fruit trees and ornamental plants in 9 villages at Gharbia governorate.

Localities (District/Village)		Snail species	Host plants and level of infestation
Al-Santa	**Mit Hawai**	*E. vermiculata*	Guava (++), mango (++) and navel orange (+++).
			Moringa (++), vasaka (++) and yellow areca palm (++).
		M. cartusiana	Guava (+), mango (+) and navel orange (+++). .
			Croton (+), moringa (+), and vasaka (++).
	Mit Yazid	*E. vermiculata*	Guava (++), mango (++) and navel orange (++).
			Croton (+), moringa (+), and vasaka (++).
		D. reticulatum	Croton (+), moringa (+), and vasaka (+)
		M. cartusiana	Guava (++), mango (++) and navel orange (++).
			Croton (+), moringa (+), and yellow areca palm (+)
	Eizbat Almalika	*S. putris*	Guava (+), mango (+) and navel orange (+).
		M. cartusiana	Guava (+++), mango (+++) and navel orange (+++).
			Croton (+), moringa (++), and vasaka (++).
Kafr-Elzayat	**El- Mansouria,**	*E. vermiculata*	Guava (++), mango (+) and navel orange (++).
			Moringa (+), vasaka (++) and yellow areca palm (+).
		M. cartusiana	Guava (+), mango (++) and navel orange (++).
	Mansheat Soliman	*E. vermiculata*	Guava (+), mango (++).and navel orange (++).
		M. cartusiana	Guava (+), mango (+) and navel orange (++).
			Moringa (++), vasaka (+) and yellow areca palm (+).
	Kafr El-Baja	*E. vermiculata*	Guava (++), mango (++) and navel orange (+++).
			Moringa (+), vasaka (++) and yellow areca palm (+).
		M. cartusiana	Guava (+), mango (+) and navel orange (++),
Zefta	**Shubra Al-Yaman**	*E. vermiculata*	Guava (++), mango (++) and navel orange (+++).
			Moringa (++), vasaka (++) and yellow areca palm (++).
		T. pisana	Guava (+++), mango (+++) and navel orange (+++).
		M. cartusiana	Guava (+), mango (+) and navel orange (++).
			Moringa (+), vasaka (+) and yellow areca palm (+).
	Kafr Shubra Al-Yaman	*E. vermiculata*	Guava (++), mango (++) and navel orange (++).
			Moringa (++), vasaka (++) and yellow areca palm (+++).
		D. reticulatum	Moringa (+), vasaka (+) and yellow areca palm (+).
		T. pisana	Guava (++), mango (++) and navel orange (+++).
		M. cartusiana	Guava (+), mango (++) and navel orange (++).
			Moringa (+), vasaka (+) and yellow areca palm (+).
	Sinbat	*E. vermiculata*	Guava (+), mango (+) and navel orange (++).
			Moringa (++), vasaka (++) and. yellow areca palm (+).
		T. pisana	Guava (++), mango (++) and navel orange (++).
		M. cartusiana	Guava (+), mango (+) and navel orange (++).

(+) = Low infestation (less than 15 nails/ sample).
(++)= Moderate infestation (between 16-30 snails / sample).
(+++) = High infestation (more than 30 snails / sample).

3.2. Seasonal population dynamics of *E. vermiculata, M. cartusiana* and *T. pisana* snails infesting Navel orange in Kafr Shobra Al-Yaman village, Zefta district, Gharbia governorate.

Survey studies indicated that *E. vermiculata, T. pisana* and *M. cartusiana* snails were the dominant species, with moderate to high population sizes on the tested fruit trees. Navel orange had the highest numbers compared to guava and mango. Therefore, population dynamics of these snail species were tested on navel orange orchards monthly from November to May in Kafr Shobra Al-Yaman village, Zefta district, Gharbia governorate during two successive growing seasons 2021/ 2022 and 2022/ 2023.

Data in Table (2) and Figs. (1, 2, 3, and 4) showed that the activity of *E. vermiculata, M. cartusiana* and *T. pisana* snails started at the beginning of November on navel orange with a relatively low population density of (7.3, 2.2, and 3.6) and (9.4, 4.4, and 6.6) snails per sample in 2021/2022 and 2022/2023 growing seasons, respectively. It was obvious that the population density of snail species slightly increased through December and January. However, in February snail numbers of *E. vermiculata, M. cartusiana* and *T. pisana* significantly increased to reach their peak in April with population density of (50.66, 31.2 and 43.4) and (55.4, 39.6 and 49.6) snails per sample on navel orange for the two successive growing seasons, respectively. However, population densities of the snails were obviously decreased during May on navel orange in the two seasons. Numbers of snails of *E. vermiculata, M. cartusiana* and *T. pisana* per sample in May, at the end of the activation period on navel orange were (33.2, 19.4, and 29.8) and (37.4, 21.1, and 31.2) snails, respectively.

Ali and Suleman (1992) studied seasonal variations in population density, *Monacha obstructa* from November 1985 to March 1987 in Pakistan. They observed maximum population densities of immatures during late spring while in the summer months, the snails were either inactive, died or aestivating, as large numbers of empty shells and dormant snails were observed. Moreover Abd El-Aal (2001) studied the aestivation of *M. cartusiana* and *Helicella vestalis* in a navel orange orchard at Sharkia governorate from April to September, (1999). He found that in early April a relatively low numbers of both species entered aestivation which gradually increased to reach the maximum value during June or July depending on the species and site of aestivation. The number of aestivated snails remained stable during the hot months until temperature and relative humidity were suitable for their activities.

Total numbers of counted *E. vermiculata, M. cartusiana* and *T. pisana* active snails on navel orange were (203.6, 139.2, and 171.6) and (234.3, 160, and 194.73) in the two successive growing seasons, respectively. The general means were (29.08, 19.88, and 24.51) and (33.48, 22.85, and 27.82), respectively. Moreover, it was observed that values of *E. vermiculata, M. cartusiana* and *T. pisana* populations were higher in the second growing season 2022 /2023 compared to those in the first one 2021/ 2022 on the navel orange. In general, it could be concluded that population density of *E. vermiculata, M. cartusiana* and *T. pisana* increased during spring season compared to low or moderate values during autumn and winter seasons.

These results agreed with those reported by Heikal (2015); Bayumi (2018); Shahawy et al. (2018); Abd-El-Haleem et al. (2019); Abo-Zaid et al. (2021); Ibrahim et al. (2021); Abd-Elhaleim et al. (2022); Bayoumi et al. (2023); Gabr et al. (2023), and Bayoumi (2024) who found that the population fluctuations increased during spring months as compared to low or moderate populations during autumn and winter months.

Table 2. Population dynamics of *E. vermiculata, M. carusiana,* and *T. pisana* snail species infesting navel orange in Kafr Shobra Al-Yaman village, Zefta district, Gharbia governorate during growing seasons 2021/ 2022 and 2022/2023 in relation to temperature and relative humidity.

Date of examination	Mean number of snails / sample						Temperature (˚C.)		R.H. (%)	
	Eobania vermiculata		*Monacha carusiana*		*Theba pisana*					
	2021/2022	2022/2023	2021/2022	2022/2023	2021/2022	2022/2023	2021/2022	2022/2023	2021/2022	2022/2023
Nov. 1st	7.3	9.4	2.2	4.4	3.6	6.6	21.33	22.57	64.12	66.31
Dec. 1st	11.2	13.5	6.4	8.2	6.33	9.33	18.64	16.965	65.81	71.5
Jan. 1st	21.4	27.8	16.4	19.8	19.4	23.4	17.93	13.155	67.38	71.88
Feb. 1st	33.2	39.4	26.8	29.6	29.3	31.8	16.835	14.93	68.44	77.06
Mar. 1st	47.6	51.4	36.8	37.3	39.6	42.8	17.275	15.355	65.69	65.5
Apr. 1st	50.66	55.4	31.2	39.6	43.4	49.6	21.21	22.355	56.5	58.94
May. 1st	33.2	37.4	19.4	21.1	29.8	31.2	28.895	26.705	46.63	51.00
Total	203.6	234.4	139.2	160	171.6	194.73				
Mean± SE	29.08 ±6.32	33.48± 6.65	19.88± 4.80	22.85± 5.11	24.51± 5.83	27.82 ±6.05				

SE= standard error.

Data in Table (3) indicated that temperature showed the highest significant effect on numbers of *E. vermiculata*, *M. cartusiana*, and *T. pisana* snails during 2021-2022 season on naval orange while, temperature showed non-significant effect on numbers of *E. vermiculata, M. cartusiana,* and *T. pisana,* during 2022-2023 season on naval orange. Concerning the effect of relative humidity on population fluctuation of these snails, it was demonstrated that the highest significant effect during 2021-2022 season on naval orange while, relative humidity showed a significant effect on numbers of *E. vermiculata*, and *T. pisana* snails and non significant on *M. cartusiana* snails during 2022-2023 season on naval orange. The obtained results in agreement with Ismail (1997), Mohamed (2017), Abo-Zaid et al. (2021), Abd-Elhaleim et al. (2022), and Bayoumi (2024).

Table 3. Correlation coefficient values between relative humidity and temperature and population density of *E. vermiculata, M. carusiana,* and *T. pisan* infesting navel orange in Kafr Shobra Al-Yaman during two growing seasons at Gharabia governorate.

Snail species	Temperature (˚C.)		Relative humidity (%)	
	2021/2022	2022/2023	2021/2022	2022/2023
Eobania vermiculata	- 0.905 **	- 0.557 **	0.914 **	0.638 *
Monacha carusiana	- 0.857 **	- 0.575 **	0.854 **	0.583
Theba pisana	- 0.883 **	- 0.571 **	0.896 **	0.642 *

Each value represents correlation coefficient.
n.s = non significant.
*= Significant at 0.05 level.
**= Highly significant at 0.01 level.

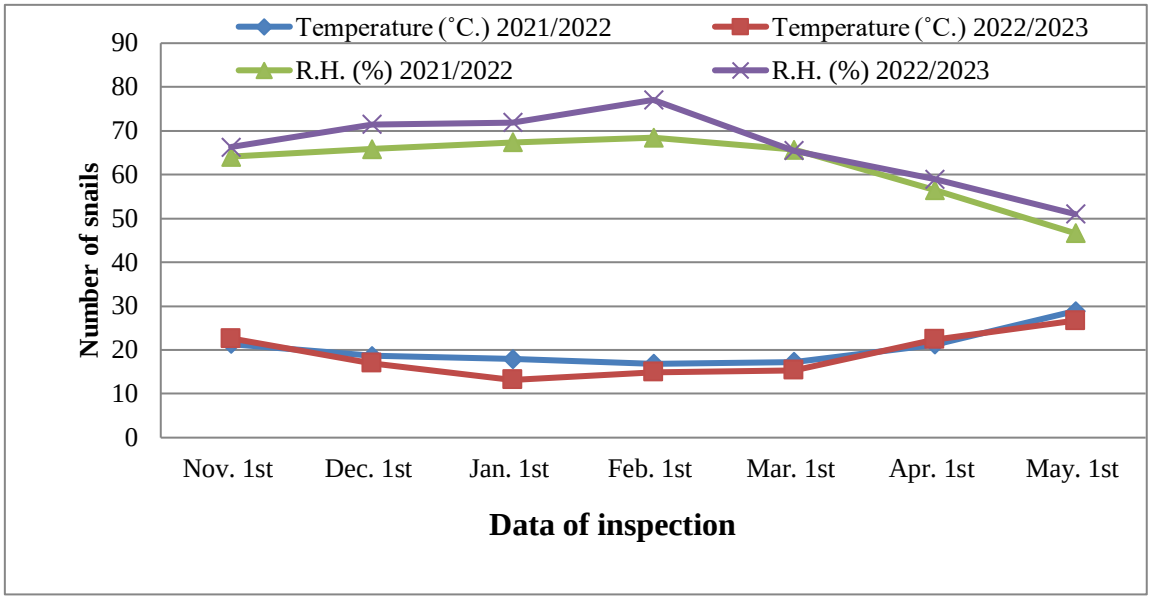

Figure 1. Temperature and relative humidity during two successive seasons, 2021/2022 and 2022/2023.

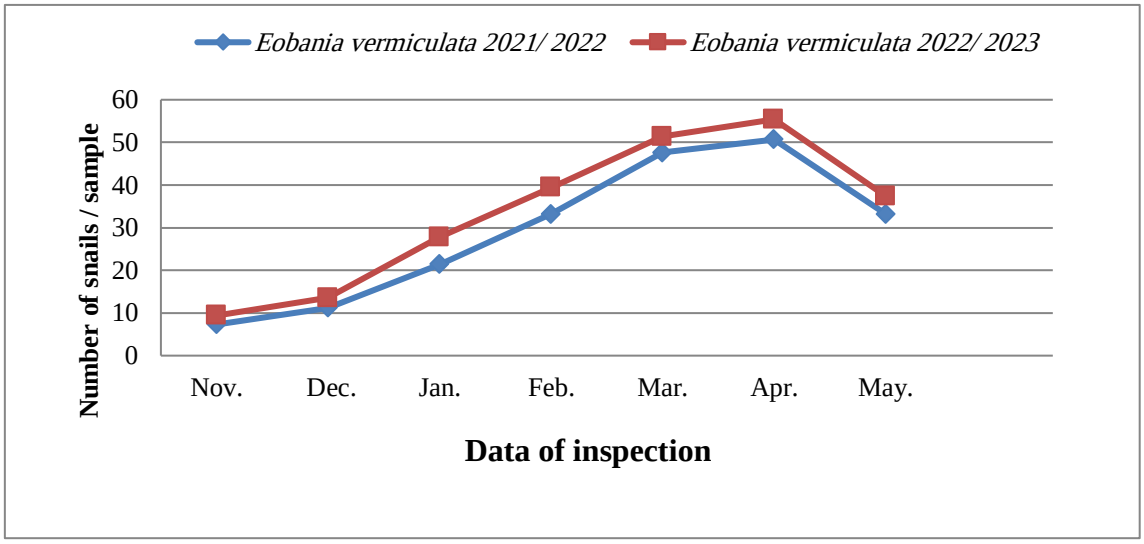

Figure 2. Population dynamics of *E. vermiculata* snail infesting navel orange in Kafr Shobra Al-Yaman village, Zefta, Gharbia governorate during 2021/ 2022 and 2022/ 2023 growing seasons.

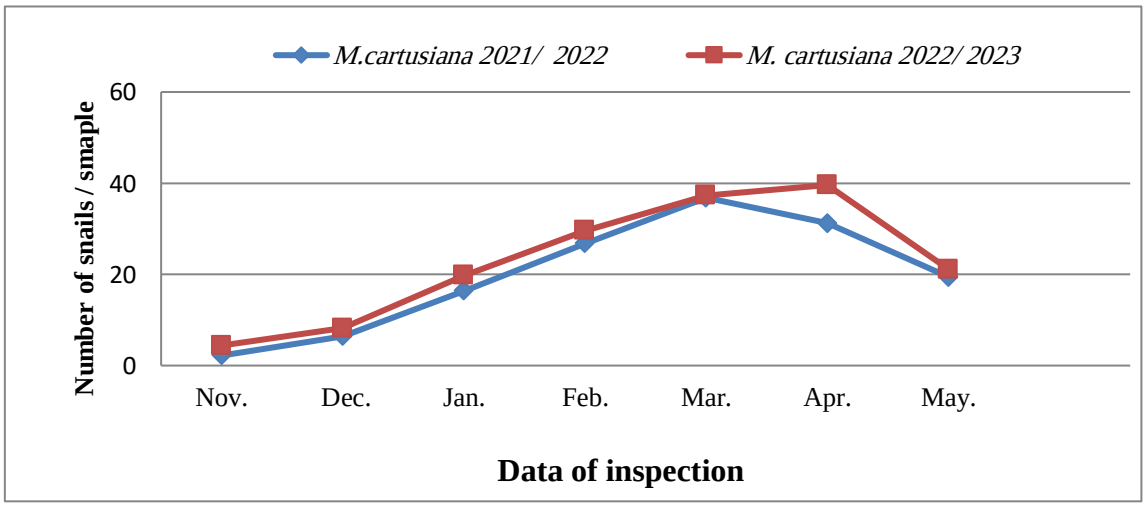

Figure 3. Population dynamics of *M. cartusiana* snail infesting navel orange in Kafr Shobra Al-Yaman village, Zefta, Gharbia governorate during 2021/ 2022 and 2022/ 2023 growing seasons.

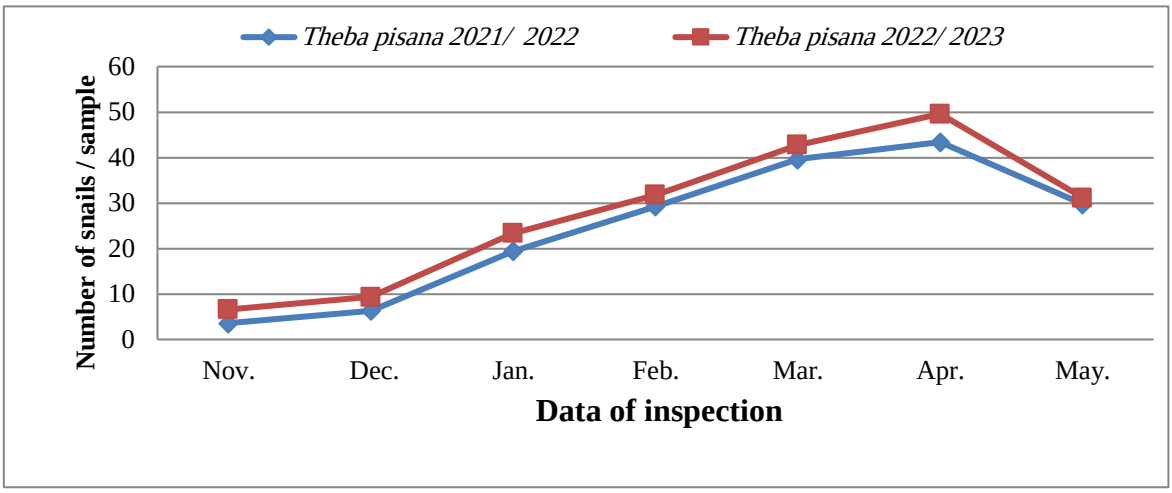

Figure 4. Population dynamics of *T. pisana* snail infesting navel orange in Kafr Shobra Al-Yaman village, Zefta, Gharbia governorate during 2021/ 2022 and 2022/ 2023 growing seasons.

4. Conclusion

Survey study was conducted on certain fruit trees and ornamental plants in Gharbia governorate during activity period started from January to April in two growing successive seasons 2021/2022 and 2022/2023. Results revealed the presence of four land snail species: *M. cartusiana*, *E. vermiculata*, *T. pisana*, and *S. putris* snails, along with the land slug *D. reticulatum*. Among these, *M. cartusiana* and *E. vermiculata* snails were the most frequently encountered, being found in all surveyed locations. *T. pisana* was less widespread, with localized occurrences in Zefta villages, while *S. putris* was found with limited incidence in Eizbat Almalika village, Al-Santa district.

The population dynamics of *E. vermiculata*, *M. cartusiana*, and *T. pisana* snails were studied on navel orange trees over two growing seasons (2021/2022 and 2022/2023). The active snails first appeared in November, with slight increases in numbers during the winter months of December and January. A significant population increase occurred in February, peaking in April, followed by a decline in May.

It can be concluded that the population size of *E. vermiculata*, *M. cartusiana*, and *T. pisana* is generally higher in spring, with lower to moderate values observed during autumn and winter months, while snails aestivate during summer months..

5. References

Abd El-Aal, E.M. (2001). Studies on certain land snails at Sharkia governorate. M.Sc. Thesis, Faculty of Agriculture, Zagazig University, 160pp.

Abd-El-Haleem, A. E.; Farag, M. F. N. G.; and Kandeel, M. M. H. (2019). Incidence and population dynamics of land snails at Sharkia governorate, Egypt. Indian Journal of Ecology, 46(4), 907-912.

Abd-Elhaleim, S.M.; Weshahy, K.; Emam, H.M.; and Ali, R.F. (2022). Population dynamics of abundant three terrestrial snail species in horticultural fields at Beheira and Giza governorate, Egypt. Pakistan Journal of Biological Sciences, 25(8), 765-775.

Abdel Kader, M. F.; Hendy, H. H.; Mustafa, M. A.; AlAkra, T. M.; and Abdel Maboud, M. F. (2016). Ecological studies on the common land snail speies in North Western Coast in Egypt. Journal of Plant Protection and Pathology Mansoura Unviversity, 7(7), 501-505.

Abo-Zaid, A.; El-Hawary, I. S.; Mahrous, M. E.; and El-Sheikh, M. F. (2021). Field observation on biology and ecology of terrestrial snails infesting field and vegetable crops at Gharbia governorate. Egyptian Academic Journal of Biological Sciences, B. Zoology, 13(2), 95-103.

Ali, N.; and Suleman, M. (1992). Seasonal variations in population density and activity of the land snail, *Monacha obstructa* at Peshawar Univ. Campus. Pakistan. Journal of Zoology, 24(1), 85-88.

Ali, R.F.; and Ramdane R. (2020). Taxonomic key as a simple tool for identifying and determining the abundant terrestrial snails in Egyptian fields (Gastropoda, Pulmonata: Succineidae, Geomitridae, Helicidae, Hygromiidae). Egyptian Academic Journal of Biological Sciences, B. Zoology, 12: 173-203.

Baker, G. H. (1988). Dispersal of *Theba pisana* (Mollusca: Helicidae). Journal of Applied Ecology, 889-900.

Baker, G.H. (1989). Damage, population dynamics, movement, and control of pest helicid snails in Southern Australia. In: British Crop Protection Council (BCPC) Monograph, No. 41. Slugs and Snail Pests in Agriculture. Ed. Henderson, I.F., 175-185, 24-26, Sept.1996.

Barker, G. M. (2002). Molluscs as crop pests. CAB International Publishing, 468 pp.

Baur, A.; and Baur, B. (1993). Climatic warming due to thermal radiation from an urban area as possible cause for the local extention of land snails. Journal of Applied

Ecology, 30, 333-340.

Bayoumi, Sh. F.(2018). Environmental studies on certain land snails under different conditions at Sharkia governorate. Master of Science, Institute of Environmental Researches, Ain Shams University, 134pp.

Bayoumi, Sh. M. F. (2024). Studies on some terrestrial gastropods at Sharkia governorate. Doctor of Philosophy, Faculty of Technology and Development, Zagazig, University, 183 pp.

Bayoumi, Sh. M.; Omar, N. A; Mohanna, A. H.; Ismail, S. A. A.; Abed, M.; El Sayed, A. M. A.; and Issa, M. A. (2023). Survey and population dynamics of land snails at Sharkia governorate, Egypt. Brazilian Journal of Biology, 84, e271247.

Castielleio, J.; Seijas, I.; and Villoch, F. (1996). Slug and snail pests in Spanish crops and their economical importance. In: British Crop Protection Council (BCPC) Monograph, No. 66. Slugs and Snail Pests in Agriculture. Ed. Henderson, I.H., 327-332.

Chen, D.N. (1994). Dangerous agriculture pests, some terrestrial molluscs. Plant Quarantine (Shanghaii), 8 (1), 37-44.

Costat (2005). Version 6.311, Copyright©, CoHort Software, 798 Lighouse Ave. PMB 320, Monterey, CA, 93940, USA.

Desoky, A. S. A.; Sallam, A. A.; and Abdel-Rahman, T. M. M. (2015). First record of two species from land snails *Monacha obstracta* and *Eobania vermiculata* in Sohag governorate, Egypt. Direct Research Journal of Agriculture and Food Science, 3 (11), 206-210.

Heikal, M. H. (2015). Biological aspects and population dynamics of three terrestrial snails infesting fruit trees in Egypt. International Journal of Advance Research Biological Sciences, 2(1), 169– 180.

El-Deeb, H. I.; Ghamry, E. M.; El-Hawashy, N.; and Essa, N. (1996). Relative abundance of some land snails in certain governorates of Egypt. Journal of Agricultural Science, Mansoura University, 21 (8), 2922-2933.

El-Kady, G. A.; Magdy, S. A.; El-Danasoury, H. M.; and El-Sharabasy, H. M. (2023). Incidence of terrestrial snails and slugs associated with certain cultivated plants from different localities at Ismailia Governorate. International Journal of Scientific Research and Sustainable Development (IJSRSD), 6(2), 1 – 9.

El-Okda, M. K. (1984). Land mollusca infestation and chemical control in El-Ismaelia governorate. Agricultural Research Review, 62 (1), 87-92.

El-Okda, M. K. (1981). Locomotion activity and infestation abundance of certain terrestrial mollusca in fruit orchard, Alexandria province, ARE. Proceedings of 4th Arab Pest. Conf., Tanta Univ., Egypt 2: 279 – 287.

Ezzat, S.A. (2021). Toxicological and biochemical studies on some land snails at Sharkia governorate. A Doctor of Philosophy, Faculty of Technology and Development, Zagazig University, 289 pp.

Gabr, L. S.; Ragheb, D. A.; Mahrous, M. E.; and Abd El-Aal, A. (2023). Occurrence, population density and seasonal population dynamics of land snails infesting major crops in Dakahlia governorate, Egypt. Zagazig Journal of Agricultural Research, 50(5), 637-649.

Gazzy, A. A.; Mostafa, N. M.; and Shahawey, W. A. (2018). Ecological studies on common land snail species infesting guava and navel orange orchards in two regions at Kafr El-Sheikh governorate. Journal of Plant Protection and Pathology, Mansoura University, 9(11), 747-750.

Gazzy, A. A.; Mostafa, N. M.; and Shahawey, W. A. (2019). Survey, population dynamics and estimation of damage of common land snail species on some vegetable plants and Egyptian clover at some regions at Kafr El-Sheikh governorate. Journal of Plant Protection and Pathology, Mansoura University, 10(1), 13-18.

Godan, D. (1983). Pest slugs and snails, biology, and control. Springer-Verlag, Berlin, Heidelberg, 445 pp.

Grewal, P.S.; Grewal, S.K.; Tan, L.; and Adams, B.J. (2003). Parasitism of mulluscs by nematodes : Types of associations and evolutionary trends. Journal of Nematology, 35 (2), 146-156.

Ibrahim, H. A. M.; El-Mesalamy, A. F. M.; Baghdadi, S. A. S.; and Elhanbaly, R. A. (2021). Species diversity and population dynamics of the prevailing land gastropod species on certain crops at Assiut governorate, Egypt. Archives of Agriculture Sciences Journal, 4(1), 291-301.

Ibrahim, M. M. A.; Lokma M. E.; and Issa M. A. (2017). Economic threshold, injury levels and food preference of glassy clover snail, *Monacha cartusiana* (Muller) Infesting strawberry plants at Ismailia Governorate, Egypt. Egyptian Academic Journal of Biological Sciences, H. Botany, 8(2), 11-20. http://dx.doi.org/10.21608/ eajbsh. 2017.16763.

Iglesias, J.; Castillejo, J.; and Castro, R. (2003). The effects of repeated applications of the molluscicide metaldehyde and the biocontrol nematode *Phasmarhabditis hermaphrodita* on molluscs, earthworms, nematodes, acarids and collembolans: a two-year study in north-west Spain. Pest Management Science (Formerly Pesticide Science), 59(11), 1217-1224.

Ismail, Sh. A. A. (1997). Ecology, biology and control of certain terrestrial snails infesting some vegetable and field crops in Sharkia governorate.A Doctor of Philosophy, Faculty of Agriculture, Zagazig University, 128 pp.

Ismail, Sh. A.; Ghaly, M. F. I.; El-Sayd, A. E.; Abdel-Kader, S.; and El-Sayd, A. (2017). Ecological studies on some land gastropod species at Zagazig district, Sharkia governorate. Journal of Plant Protection and Pathology, Mansoura University , 8(8), 425-429.

Ismial, Sh. A. A.; Shetaia, S. Z. S.; Arafa, A. I.; and

Abde-Atty, A. F. (2011). Incidence and seasonal fluctuation of certain land gastropod species associated with some crops and weeds at Sharkia governoate. Journal of Plant Protection and Pathology, Mansoura University, 2 (2), 1103-1110.

Mahrous, M. E.; Ibrahim Mervt, H.; and Abdel-Aal, E. M. (2002). Occurance, population density and importance value of land snails infesting different crops in Sharkia governorate, Egypt. Zagazig Journal of Agricultural Research, 29 (2), 613-629.

Mohamed, Gh. R. (2015). Incidence of land snails inhabiting different vegetations at some governorates in North-East of Delta , Egypt . Journal of Plant Protection and Pathology, Mansoura University, 6(6), 899-907.

Mohamed, M. A. A. (2017). Application of some integrated control methods on some land snail species in Sharkia governorate, Egypt. A Doctor of Philosophy, Faculty of Science, Al-Azhar University, 146 pp.

Rady, G. H. (2019). Survey and population density of land snails under different conditions at Qalubia and Sharkia governorates. Annals of Agricultural Science, Moshtohor, 57(3), 755-760.

Rady, G. H.; Abdel-Gawad, A. A.; Ismail, Sh. A. A.; and Lokma, M. H. (2014). Ecology of some terrestrial mollusks in Sharkia and Ismailia governonrates. Egypt. Journal of Agricultural Research, 92 (3), 907-920.

Rashed, A. A. (2008). A new parasitic metacercaria from the land snail *Monacha obstructa* Preiffer 1842 with critical review on relevant metacercariae belonging to the genus *Brachylaima* Dujardin 1843. Journal of the Egyptian Society of Parasitology, 38: 483-500.

Shahawy, W. A.; Mostafa, N. M.; and El-Tahawe, H. S. (2018). Population density, food consumption and damage caused by the land snail *Monacha cantiana* to some vegetable crops at Kafr El-Sheikh governorate. Journal of Plant Protection and Pathology, Mansoura University, 9(9), 601- 604.

Stakikou, A.; and Lazaridou-Dimitriadou, M. (1990). Aspects of the life cycle, population dynamics, growth and secondary production of the snail *Monacha cartusiana* (Muller, 1884) (Gastropoda: Pulmonata) in Greece. Malacologia, 31 (2), 353-362.