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Allocation and survey dynamics of *Monacha cartusiana* (Gastropoda: Hygromiidae) terrestrial snail at Fayoum Governorate cultivations

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Abstract

A field allocation and survey for *Monacha cartusiana* (O. F. Müller) (Gastropoda: Hygromiidae) terrestrial snail was done at Fayoum governorate in three districts of Zawyt-Alkradesa, Talat village, and Nazlat Al-Harrishi during the two growing seasons of 2022-2023 and 2023-2024 on different crops and vegetables cultivated in the mentioned districts. Results revealed that only one species of terrestrial snail, *M. cartusiana*, showed a varied allocation range in all surveyed villages. Highly dense populations of snails were found on the clover, followed by lettuce, cabbage, and wheat. While brood bean, courgette, and onion showed fewer populations and zero on garlic, the initial infestation of *M. cartusiana* on the clover appeared in October with a low population (1, 2 snails per quadratic sample) and (2, 2.4 snails per quadratic sample) at the beginning and mid-October months, whereas it reached its maximum on 15th April (64.6, 75.2 snails per quadratic sample) during the two seasons. Meanwhile, the initial infestation with *M. cartusiana* appeared on wheat during December with a low population and reached its maximum on 15th April (32.2, 36.2 snails per quadratic sample) during the two growing seasons. Population dynamics in *M. cartusiana* juveniles and adults fluctuated at a partially low population during the October and November months. Meanwhile, it gradually increased during December, January, February, and March, reaching its maximum on April 15th for juveniles and adults. Then, the infestation had another decline during May.

Introduction

Mollusca are considered one of the most successful phyla in the animal kingdom. Gastropods are the most successful mollusks that have invaded land. In the 20th century, gastropods emerged as important crop pests in temperate and tropical regions. The increased pest status has been associated with the cultivation of new crops, the intensification of agricultural production systems, and the spread through human trade and travel of species adapted to these modified

environments (Barker, 2002). The glassy clover snail *Monacha cartusiana* (O. F. Müller) (Gastropoda: Hygromiidae) spreads in the wide natural geographical distribution of Mediterranean countries and the Middle East region (Ezzughayyar *et al.*, 1996; Hausdorf, 2000; Neubert and Bariche, 2013 and Neubert *et al.*, 2015) and also in Egyptian governorates as the most broadly spread agricultural pest on different field crops, fruit orchards, vegetables, ornamental plants, and other various plantations (Mahrous *et al.*, 2002). In Egypt, land snails have increased and distributed rapidly in different localities. They significantly harmed ornamental plants and vegetable and fruit crops where they found the best conditions for survival and reproduction (Asran, 1994). The distribution range of land snail species has rapidly increased and expanded from the Delta region, where there is more humid and low temperature, to the Upper Egypt region, such as Fayoum, where there is more dry and warm weather. Therefore, more ecological aspects such as field distribution and population dynamics have been studied for many successive years on field crops (Metwally *et al.*, 2002 and El-Deeb *et al.*, 2004). Land snails are thought to be among the most damaging agricultural pests in the Sharkia governorate, severely damaging orchards, field crops, and vegetables (Ghamry *et al*., 1993 and Ismail *et al.*, 2011). Land snails caused damage involving considerable financial loss to different crops in different localities in Egypt (Shahawy *et al*., 2018).

The current work aims to allocate and survey the most important endemic gastropods and population dynamics for the most common land snail species that infest different field crops and vegetable cultivation in Fayoum governorate, Egypt. Also, population dynamic estimation for *M. cartusiana* on Egyptian clover, *Trifolium alexandrinum* (Fabaceae), and wheat, *Triticum aestivum* (Poaceae) cultivations. In addition, juvenile and adult *M. cartusiana* populations fluctuate on Egyptian clover.

Materials and methods

1. Study area:

The current study was conducted in three districts, i.e., Zawyt-Alkradesa, Talat village, and Nazlat Al-Harrishi districts, Fayoum governorate, during the two growing seasons 2022-2023 and 2023-2024.

2. Host plants:

The host plant species in this work were: field crops such as Egyptian clover, wheat, broad bean, garlic, and onion; and vegetable crops such as cabbage, lettuce, and courgetti.

3. Survey dynamics:

3.1. Random survey of *Monacha cartusiana* on host plants:

In all work areas, the terrestrial snail species were counted early in the morning in each host plant area per field crop and above the soil surface using a quadrate sample at 50x50cm **(Staikou and Lazaridou-Dimitriadu, 1990).**

3.2. Population dynamics of *Monacha cartusiana* on clover and wheat:

The population dynamics of *M. cartusiana* snails were studied on a field cultivated with clover and another with wheat at Fayoum Governorate during two successive growing seasons (2022-2023 and 2023-2024). About one faddan was cultivated for every crop, and five replicates per quadrate sample size (50 x 50 cm) for each faddan were examined monthly using the method mentioned previously.

3.3. Seasonal population fluctuation of *Monacha cartusiana* juveniles and adults:

Monthly fluctuation in numbers of the predominant snail, *M. cartusiana*, was determined on the infested field that was cultivated with clover and

another with wheat in Fayoum districts during 2022-2023 and 2023-2024. As per the same method mentioned before, the alive juveniles and adult snail individuals found on both plants and above the soil surface in the quadrate sample were counted and used to estimate the population fluctuations.

4. Statistical analysis:

All work data were statistically analyzed using Costat Statistical Program Software (1990) and then Duncan's Multiple Range Test (Duncan, 1955) at 5% probability level to compare the differences among means.

Results and discussion

1. *Monacha cartusiana* survey on certain cultivations:

A survey was done on terrestrial snails that were infesting different crops at three locations in the Fayoum Governorate. Data presented in Table (1) revealed that one species (*M. cartusiana*) of terrestrial snails was found on different crops. The tested hosts can be classified into four categories according to the infestation degree with *M. cartusiana*. These categories were: heavy, moderate, light, and zero infestation. The majority of the examined crops were found to have a heavy infestation, especially clover^{+++}, lettuce^{+++} and a moderate infestation of cabbage^{++}, wheat^{++}, and a light infestation of brood bean^{+}, courgettes, onion^{+}, and zero on garlic at Zawyt-Alkradesa, Talat village, and Nazlat Al-Harrishi at Fayoum Governorate.

Population density of terrestrial snails, *M. cartusiana*, was counting on the leaves, branches, and soil surface of Egyptian crops (Clover, lettuce, wheat, and cabbage) in three locations at Fayoum Governorate during the two successive growing seasons of 2022-2023 and 2023-2024. Also, as presented in Table (2), the Population density of snails during the first season showed approximately a similar trend as that found in the second season.

Table (1): *Monacha cartusiana* land snail survey and infestation on certain cultivations at Fayoum Governorate during 2022-2023 season.

Districts	Host plants
Zawyt-Alkradesa	clover^{+++}, lettuce^{+++}, wheat^{++}, cabbage^{++}, onion $^{+}$, brood bean^{+}, garlic^{0}
Village of Talat	clover^{+++}, cabbage^{++}, Lettuce^{+++}, wheat^{++}
Nazlat Al-Harrishi	clover^{+++}, cabbage^{++}, Lettuce^{+++}, courgettes^{+}

(+++) = heavy infestation (more than 30 snails/50x50cm)
(++) = moderate infestation (more than 16-30 snails/50x50cm)
(+) = light infestation (more than 1-15 snails/50x50cm)
(0) = no infestation

2. Population dynamics of *Monacha cartusiana* on Egyptian clover and wheat:

2.1. Egyptian clover:

During 2022-2023 season, the highest population density of snails appeared in April **(**Table 2). The highest mean numbers of snails were 60 and 64.6 snails/m^2 on the 1st and 15th in April. However, the lowest mean numbers were 1 and 2 snails/m^2 on first and mid-October. While the population density of snails during the 2023-2024 season showed approximately a similar trend as that in the 2022-2023 season.

2.2. Wheat:

Initial infestation of the *M. cartusiana* snails appeared on 1st December on wheat with relatively low population densities of 2.2 and 4 snails per quadrate size 50 x 50 cm in the growing seasons 2022-2023 and 2023-2024 at Fayoum Governorate, respectively. Regarding the population behavior of *M. cartusiana*, it was clear that the population of snails was highly increased to reach its maximum of 32.2 and 36.2 snails per quadrate sample size (50 x 50 cm) on 15th April for the

growing seasons 2022-2023 and 2023-2024.

It was observed that the highest population density of *M. cartusiana* was recorded during the spring months (March and April) as compared with the winter and autumn months. Also, there was a steadily increasing population density, as indicated by the general mean value of population density, which was much higher (33 snails per quadratic sample) on Egyptian clover during 2023/2024 than (29.05 snails per quadratic sample) at 2022/2023, followed by wheat (18.86 snails per quadratic sample) at 2023/2024 than (10.79 snails per quadratic sample) at 2022-2023. Heat and abundance increased during the February, March, and April months as compared to the other months.

Table (2): *Monacha cartusiana* land snail population dynamics during the 2022-2023 and 2023-2024 growing seasons on Egyptian clover and wheat at Fayoum Governorate.

Months	Mean number of snails/samples				Temp (Ċ.)		R.H. (%)	
	Egyptian clover *Trifolium alexandrinum*		Wheat *Trifolium aestivum*					
	Season 2022 / 2023	Season 2023 / 2024	Season 2022 / 2023	Season 2023 / 2024	Season 2022 / 2023	Season 2023 / 2024	Season 2022 / 2023	Season 2023 / 2024
Oct.1st	1 g	2 j	0.0 j	0.0 h	25.01	25.36	53.91	55
Oct.15th	2 fg	2.4 j	0.0 j	0.0 h	23.21	24.66	56.57	54.84
Nov.1st	6.2 efg	6 ij	0.0 j	0.0 h	20.19	24.20	57.31	58.41
Nov.15th	8.8 ef	9.6 i	0.0 j	0.0 h	17.90	18.86	58.81	60.09
Dec.1st	12.6 e	15 h	2.2 ij	4 g	17.24	16.58	57.41	59.98
Dec.15th	19.6 d	21.4 g	4.8 hi	6.8 f	15.62	16.40	67.59	69.85
Jan.1st	20 d	22 g	4.2 i	6 f	13.86	13.51	67.47	62.76
Jan.15th	25.6 c	29.8 f	9.2 fg	10.4 e	13.63	13.59	61.29	57.61
Feb.1st	28 c	40 e	7 gh	12 e	11.48	12.04	61.22	62.10
Feb.15th	38.2 b	46.2 d	14.8 e	16.2 d	12.69	14.74	67.88	56.69
Mar.1st	45 b	48 d	19.6 d	18.6 c	18.83	16.84	46.48	52.23
Mar.15th	59.4 a	6 1.2 c	25c	25.8 b	17.55	18.41	50.69	47.35
Apr.1st	60 a	66 b	28.6 b	35.8 a	20.74	21.68	42.35	47.10
Apr.15th	64.6 a	75.2 a	32.2 a	36.2 a	23.16	25.00	39.61	37.00
May 1st	44 b	50 d	14.8 e	18 cd	23.67	23.62	41.29	42.68
May 15th	30.8 c	33.2 f	10.2f	11.8 e	27.32	28.09	37.51	32.63
Total	464.8	528	172.6	301.68				
Mean	29.05	33	10.79	18.86				
F. value	0.719	1.4303	0.775	2.7552				
L.S.D.0.05	6.491	4.548	2.611	1.9177				

3. Seasonal population fluctuation of *Monacha cartusiana* juveniles and adults are infesting clover fields:

Survey work showed that *M. cartusiana* snail was the predominant species; therefore, seasonal population fluctuations of *M. cartusiana* snails, juvenile and adults, were studied on Egyptian clover and *Trifolium alexandrinum* (Fabaceae) fields during the two growing seasons 2022-2023 and 2023-2024 at Fayoum Governorate.

Data in Table (3) revealed that adults of *M. cartusiana* snails were found in clover fields throughout the year. The lowest monthly number was determined in October. Counted adult snails per sample (1 and 2 adults/0.25 m^2), followed by 6.2 and 7.8 adults/0.25 m^2 and 2 and 2.4 adulst/0.25 m^2, 6, 8.4 adult/0.25 m^2 at 1st & 15th during October and November at 2022/2023 and 2023/2024, respectively.

Table (3): Seasonal population fluctuation of *Monacha cartusiana* juveniles and adults of terrestrial snails infest Egyptian clover at Fayoum Governorate.

Month	Mean number of snails/samples			
	Juvenile	Adult	Juvenile	Adult
	Season 2022/ 2023		Season 2023 / 2024	
Oct.1st	0.0 h	1 h	0.0 h	2 h
Oct.15th	0.0 h	2 gh	0.0 h	2.4 h
Nov.1st	0.0 h	6.2 fg	0.0 h	6 g
Nov.15th	1 gh	7.8 ef	1.2 gh	8.4 fg
Dec.1st	4.2 fg	8.4 ef	4.6 g	10.4 ef
Dec.15th	6 ef	13.6 cd	7.2 f	14.2 e
Jan.1st	11.6 d	8.4 ef	8.8 f	13.2 e
Jan.15th	14 d	11.6 cde	16.8 e	13 e
Feb.1st	18.0 c	10 def	22 cd	18 d
Feb.15th	22 c	16.2 c	25.2 bc	21 cd
Mar.1st	24.2 b	20.8 b	26 b	22 c
Mar.15th	30.6 a	28.8 a	38 a	23.2 c
Apr.1st	31.6 a	28.4 a	40 a	27 b
Apr.15th	33.4 a	31.2 a	40.6 a	34.6 a
May 1st	15 cd	29 a	18.6 de	31.4 a
May 15th	8 e	22.8 a	15 e	18.2 d
Total	219.6	246.2	264.0	264.73
Mean	13.725	15.388	16.5	16.483
F. value	0.869	1.0042	1.163	6.585
L.S.D.0.05	3.240	4.532	3.488	3.533

Also, it was mentioned that the juvenile *M. cartusiana* snails were found throughout the 15th November to May months. The lowest values of population density were determined during November. The numbers of counted juvenile snails per sample were 1 and 1.2 juvenile snails per 0.25 m^2 at mid-November in 2022/2023 and 2023/2024, respectively. The values of juvenile and adult population density gradually increased to reach their maximum values during the spring months. The highest population densities of adults were detected in mid-April 2022/2023 and 2023/2024 (31.2 and 34.6 adults/0.25 m^2), respectively. Also, the highest population densities of juveniles were 33.4 and 40.6 adults/0.25 m^2 in 2022/2023 and 2023/2024.

It could be concluded that terrestrial snails recorded higher infestation levels during March and April as compared with May. These results were adopted from the findings of Shahawy *et al*. (2018), Khidr (2015), and Khidr *et al*. (2020). Also, most of the chosen plants were found to be infested with *M. cartusiana*; this finding is quite similar to those previously found by Shetaia *et al*. (2009); Ismail *et al*. (2011), and Abou Senna *et al*. (2016), who reported the majority of examined vegetable and field crops were found heavily infested with *M. cartusiana* at Sharkia Governorate. Also, Ismail *et al*. (2017) and Kadry *et al*. (2018) reported that the field survey was carried out at Sharkia governorate and showed that *M. cartusiana* has a very wide distribution range in all surveyed villages, followed by a highly dense population of snails that were found on the clover, followed by lettuce and cabbage. In addition, they found a high-density population during the spring months (March, April, and May) throughout two successive seasons in Sharkia Governorate. Rady *et al*. (2019) studied the survey and effect of soil components on population density and distribution of land snails in Kafr Al-Gammal and Kafer Hamza

villages (Qalubia Governorate), and Sunhot and Adleya villages (Sharkia Governorate). A survey revealed that four species of land snails, *M. cartusiana, Eobaina vermiculata,* (O.F. Müller) (*Gastropoda*: Helicidae), *Succinea putris* L. (*Gastropoda*: Succineidae), and *Cochlicella acuta* (O.F. Müller) (*Gastropoda*: Geomitridae), were found in the two Governorates. All species were found in Adleya and Kafr Al-Gammal villages; while the two species, *M. cartusiana* and *S. putris* were found in Kafr Hamza village, whereas *M. cartusiana* was only found in Sunhot village. These findings indicated that the population density of land snails differed from one locality to another.

The highest population was recorded in Adleya village, while *M. cartusiana* was the most predominant species. Also, Ali and Robinson (2020) survived terrestrial mollusks during their activity season in various spots of gardens, nurseries, and agricultural fields in Cairo, Giza, as well as in some neighboring areas between December 2014 and October 2018. Several invasive terrestrial gastropod species were identified. These gastropods are invasive and abundant pests, causing considerable and serious damage to agricultural areas in the Nile Delta Region of Egypt. The specimens were collected from different locations in the governorates of Cairo and Giza. A total of 12 species (8 species of terrestrial snails and 4 of slugs) were identified by their shell characteristics and genital-anatomical characteristics, which is particularly injurious to agricultural production. The other invasive species reported in this study were recorded in other agricultural fields and are common pests of gardens, nurseries, and agricultural areas in Egypt.

Other works were done to survey and population dynamics estimation, as Rady *et al.* (2014) carried out a field study to survey the population density and importance value of terrestrial molluscs infesting some vegetable and field crops. Five species were found infesting different crops in Ismailia and Sharkia Governorates. These species were *M. cartusiana, C. acuta, S. putris, Deroceras laeve* (O.F. Müller) and *D. reticulatum* (O.F. Müller) (*Gastropoda*: Agriolimacidae). Population density was counted on the host plants in three districts of Sharkia and Ismailia Governorates during two successive growing seasons, February to May 2008 and 2009, respectively. Generally, it is clear that the glassy clover snail *M. cartusiana* was the predominant species on field and vegetable crops. On the other hand, the population density of land snails differed from one host plant to another and also from locality to another. So, the land snail species can be arranged descending according to their importance values at Sharkia and Ismailia as follows: *M. cartusiana* > *S. putris* > *D. reticulatum and M. cartusiana* > *S. putris* > *D. reticulatum* > *D. leave* > *C. acuta*, respectively. Also, Desoky *et al.* (2015) identified terrestrial gastropod species in Sohag Governorate during 2014/2015 season and found that the first record of two species of snails, *Monacha obstracta* (Montagu) (Gastropoda: Hygromiidae) and *E. vermiculata*) in the study areas. Also, they used the results in the plan development in an effective strategy for the implementation of land snails' management programs in cultivated and newly reclaimed agro-ecosystems in Egypt. In addition, the experimental laboratory and private orchards of Shebin El-Kom center, Menoufia governorate, Heikal (2015) conducted laboratory and field experiments to study some biological aspects and the seasonal fluctuation of three economic land snails infesting three fruit crops over two successive years. Regarding

the ecological studies conducted on land snails in field settings, statistical analysis of the collected data revealed significant variations in the monthly counts of each snail species infesting orange, apple, and grape trees over the course of the two-year study, as well as significant variations in the total counts of each snail infesting the three fruit crops. The two years' data showed that the snail *E. vermiculata* had the highest documented occurrence of any species of snail *E. vermiculata* (39.7%), and the highest infested crop was orange, while the lowest numbers were recorded with the *T. pisana* snail (28.5%) and grape crop. It is possible to draw the conclusion that the best time to effectively manage land snail populations is during the fall, when the snails are active and their numbers are quite low.

Meanwhile, Abou Senna *et al.*, (2016) carried out a study on certain places in Sharkia Governorate, Egypt, to survey the most common terrestrial gastropods infesting vegetable and field crops. It was revealed that most crops were highly infested with *M. cartusiana* snails, while *S. putris* and *D. laeve* had moderately to low infestations. As in the case of *Monacha cantiana* (Montagu) (Gastropoda: Hygromiidae), it was recorded for the first time in the Sharkia governorate. In terms of population dynamics, in February, March, and April, Egyptian clover had the greatest number of snails, followed by wheat and sugar beet. Meanwhile, Abd El-Halim *et al*. (2019) incidence of the most common land snails infesting various crops in two districts at Zagazig and Fakous, Sharkia Governorate, Egypt, and disclosed the existence of five species order: Stylommatophora were recorded in a different area, namely: Sheeba, Banayous, and Banishebl, Zagazig districts, and Monshaat-El-Qady, Mayit-Elaz, and El-Smanaa, Fakous districts, all at Sharkia governorate, Egypt. These species were the glassy clover snail; *M. cartusiana*, the brown grand snail; *E. vermiculata*, the conical snail; *C. acuta*; and two species of *Succinea*. The predominant one, *M. cartusiana*, was present in all surveyed villages. *S. putris* has appeared as the first recorded for the first time in Banayous village, Zagazig district, foray the Egyptian clover severely. While rice and maize were found to have the lowest levels of infection, lettuce, cabbage, and wheat were found to have intermediate levels. The population dynamics of *M. cartusiana* infesting fields of Egyptian clover were recorded in two villages, Banayous and Monshaat-El-Qady. The highest population densities of juveniles and adults were recorded in March and April, while the lowest population was observed during January and February for adults. After the winter, the number of snails gradually climbed until reaching a peak in the summer.

Recently, work done by Abd El-Halim *et al.* (2021) found the highest population density of *M. obstructa* recorded on Egyptian clover at Forkous village, Tamiya District, for both seasons used. *M. obstructa* recorded almost every month on Egyptian clover was more than wheat during the two successive seasons; however, the population density recorded less for the Egyptian clover season of 2016–2017 was superior to that of 2017–2018 in the Dar Ramad site in the Fayoum District. The seasonal population dynamics gave a clear image of the snail's behavior and dispersal that will lead to the good design of an effective integrated pest control program or strategy against the pest with a full understanding of the other climatic and environmental factors.

The terrestrial snail, *M. cartusiana*, showed a varied allocation range in all three surveyed districts at

Fayoum Governorate. A highly dense population of snails was found on the clover, followed by lettuce, cabbage, and wheat. While brood bean, courgetti, and onion showed less population and zero on garlic. The initial infestation of *M. cartusiana* on the clover appeared in October with a low population, whereas it reached its maximum on the 15th of April; meanwhile, the initial infestation with *M. cartusiana* appeared on wheat in December with a low population and reached its maximum on the 15th of April during the two seasons (2022/2023–2023/2024).

Population dynamics of *M. cartusiana* juveniles and adults fluctuated at a partially low population during October and November months; gradually increased during December, January, February, and March till reaching a maximum on 15th April for juveniles and adults, and the infestation had another decline during May.

References

Abd El-Halim, S.M.; Ali, I.H.H.; El-Sayed, Sh. A.M. and Ali, R.F. (2021): Preliminary study on survey and population dynamic of the terrestrial Snail, *Monacha obstructa* (Pfeiffer) (Hygromiidae, Mollusca) at crop fields in Fayoum governorate, Egypt. Pak. J. Biol. Sci., 24 (9): 928-938. DOI: 10.3923/pjbs.2021.928.938

Abd El-Halim, S.M.; Farag, M.F. and Kandil, M.M. (2019): Incidence and population dynamics of land snails at Sharkia governorate, Egypt., Indian Journal of Ecology, 46(4): 907-912.

Abou Senna, F.M.; Almaraghy, A.H.A.; Ismail, Sh. A. A. and Abed, M. (2016): Survey, population dynamics of terrestrial Gastropod infesting certain crops at Sharkia governorate, Egypt. Int. J. Adv. Res., 4(11): 641-649. DOI:10.21474/IJAR01/2128

Ali, R.F. and Robinson, D.G. (2020): Four records of new to Egypt gastropod species including the first reported Tropical Leatherleaf slug *Laevicaulis alte* (Ferussac, 1822) (Pulmonata: Veronicellidae). Zoology and Ecology, 30(2): 138-156. DOI:10.35513/21658005.2020.2.8

Asran, F. D. A. (1994): Studies on harmful terrestrial snails and their management on Egyptian agricultural lands. M.Sc. Thesis, Instit. Environ. Stud. and Res., Ain Shams University.

Barker, G.M. (2002): Mollusks as crop pests. CABI Publishing, Wallingford, UK, pp. 468.

Costat Statistical Program Software (1990): Microcomputer program analysis, version 4.20, CoHort Software, Berkley, CA, USA. https: // doi .org 10.1016 /j. biocontrol. 2005.05.013.

Desoky, A.S.S.; Sallam, A.A. and Abd El-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 (DRJAFS), 3(11): 206-210.

Duncan, D.B. (1955): Multiple range and multiple F test. Biometrics., 11:1-42. https://doi.org/10.2307/3001478

El-Deeb, H.I.; Abdel-Halim, A.; Koutb, I.; Khidr, F.K. and Edress, N.M. (2004): Studying some ecological aspects associated with the prevalent land snails at Kafr El-Sheikh governorate. J. Agric. Sci. Mansoura Univ., 29: 2847-

2853. DOI: 10.21608/jppp.2004.239717

Ezzughayyar, A.; Al-Zawahra, M. and Salem, H. (1996): Molluscan fauna from site 4 of Tell Jenin (Northern West bank-Palestine). J. Archaeol. Sci., 23: 1-6. https://doi.org/10.1006/jasc.1996.0001

Ghamry,E.M.; El-Deeb, H.I. and Katab ,Y.A. (1993): Ecological and morphological studies on certain land snails at Sharkia Governorate. Egypt.J.Appl.Sci.,8 (11) :213-225.

Hausdorf, B. (2000): The genus *Monacha* in Turkey (Gastropoda: Pulmonata: Hygromiidae). Archiv Molluskenkunde, 128: 61-151. DOI:10.1127/ARCH.MOLL/128/2000/61

Heikal, H.M. (2015): Biological aspects and population dynamics of three terrestrial snails infesting fruit trees in Egypt. Int. J. Adv. Res. Biol. Sci., 2(1): 169–180.

Ismail, Sh. A. A.; Shetaia, S.Z.S.; Arafa, A.I. and Abd-El-Atty, S.F. (2011): Incidence and seasonal fluctuations of certain land gastropod species associated with some crops and weeds at Sharkia governorate. J. Plant Prot. Path., Monsoura Univ., 2 (12): 1103-1110. DOI:10.21608/jppp.2011.86641

Ismail, Sh. A.A.; Issa, M.A.; Shetaia, S.Z.S. and Khattab, M.M. (2017): Dispersal of the land Snail *Eobania vermiculata* in citrus orchards in Sharkia governorate. J. Plant Prot. and Path., Mansoura Univ., 8(4): 177-180. DOI: 10.21608/jppp.2017.46189

Kadry, W.M.; Abd-Elmageed, A.E.; Boules, M.W. and Bayoumi, Sh. M. (2018): Survey and population dynamics of some land snails infesting different plant hosts at Sharkia Governorate. J. Environ. Sci., 42 (1): 110-112. DOI:10.21608/JES.2018.21617

Khidr, E.k. (2015): Effect of some environmentally safety biopesticides on some land mollusks species in Qalubia and Sharkia Governorates. PhD. Ain Shams University.

Khidr, E.K.; Mahmoud, K.W. and Abd El-Rahman, A.H.E (2020): Movement and seasonal activity of land snails *Theba pisana* and *Eobania vermiculata* (Gastropoda: Helicidae) on citrus orchards at Qalubiya and Sharkia governorates. Egypt. J. Plant Prot. Res. Inst., 3 (2):724–730.

Mahrous, M.E.; Ibrahim, M.H. and Abdel-Ala, E.M. (2002): Occurrence, population density and importance value of land snails infesting different crops in Sharkia Governorate, Egypt. Zagazg J. Agric. Res., 29: 613-629.

Metwally, A.M.; Zedan, H.A.; El-Saeid, A.B. and El-Akra, T.M.M. (2002): Ecological studies on certain land snails in Monofia and Gharbia governorates. Proceedings of 2nd International Conference, Plant Protection Research Institute, Cairo, Egypt. Plant Protection Research Institute (PPRI), 70-79.

Neubert, E. and Bariche, M. (2013): On the *Monacha* species of Lebanon (Gastropoda: Hygromiidae). ZooKeys, 311: 1-18.

DOI:10.3897/zookeys.311.5408

Neubert, E.; Amr, Z.S.; Waitzbauer, W. and Talafha, H.A. (2015): Annotated checklist of the terrestrial gastropods of Jordan (Mollusca: Gastropoda). Archiv Molluskenkunde Int. J. Malacol., 144: 169-238. DOI: 10.1127/ARCH.MOLL/1869-0963/144/169-238

Rady, G.H.; Abdel-Gawad, A.A.; Ismail, Sh. A. and Lokma, M.H. (2014): Ecology of some terrestrial molluscs in Sharkia and Ismalia governorate. Egypt. J. Agric. Res., 92 (3): 907-920. DOI: 10.21608/ejar.2014.156353

Rady, G.H.H.; Fouad, M.M.; Mohamed, Gh. and Mohamed, M.E. (2019): Survey and population density of land snails under different conditions at Qalubia and Sharkia governorates. Annals of Agric. Sci., Moshtohor, 57(3): 755-760. DOI:10.21608/assjm.2019.98138

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. J. Plant Prot. and Path., Mansoura Univ., 9 (9): 601- 604. DOI: 10.21608/jppp.2018.43889

Shetaia, S.Z.S.; Ismail, Sh. A. and Abdel-Kader, S.M. (2009): Survey, population dynamics and importance value of certain land snail species infesting different crops in Sharkia governorate, Egypt. Acad. J. Biolog. Sci., 1(1): 37-43. DOI:10.21608/EAJBSZ.2009.16020

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