RESEARCH | Egyptian Journal of Agricultural Research | PLANT PROTECTION

Seasonal variations in abundance and distribution of *Theba pisana* (Müller) snail on different citrus varieties in Sharkia Governorate, Egypt

Mohamad Abed[*]; *Mohamed A. Issa and Mohamed I. El-Bakhshawngi*

Address:

Plant Protection Research Institute, Agricultural Research Centre, Giza, Egypt

*Corresponding author: ***Mohamad Abed.*** email: drmohamadabed85@gmail.com

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ABSTRACT

This study investigated the seasonal population dynamics (horizontal and vertical distribution) of the snail *Theba pisana* (Müller) under field conditions of three citrus varieties at Sharkia Governorate, Egypt, during 2022-2023 growing season. The research examined both horizontal (0.5m, 1m, 1.5m from tree trunk) and vertical (0-1m, 1-2m, >2m) distribution patterns on navel orange (*Citrus sinensis*), balady mandarin (*Citrus deliciosa*), and ponkan mandarin (*Citrus reticulata*). Horizontal distribution analysis demonstrated an inverse relationship between distance from tree trunk and snails density across all varieties, with highest populations recorded at 0.5m followed by 1m. The lowest population was at a distance of 1.5 m from the tree trunk.Peaks of seasonal populations occurred during spring months (March-May) for balady mandarin and navel orangeand in March for ponkan mandarin. All varieties exhibited minimal population during summer months (July-September). In respect tovertical distribution, all varieties showed a clear preference for the middle canopy zone (1-2m), followed by lower zone (0-1m) while, the lowest snail densities were consistently observed in the upper canopy (>2m). The Seasonal fluctuations of snail population showed peak during summer months (June-August), while,the lowest population was recorded during winter months. A significant difference in population density for (horizontal and vertical distribution) between balady mandarin and both navel orange and ponkan mandarin. However, no significant difference was observed between navel orange and ponkan mandarin. Balady mandarin supported the highest overall population density followed by navel orange and ponkan mandarin.

Keywords: *Theba pisana*, citrus varieties, horizontal and vertical distribution.

INTRODUCTION

Terrestrial gastropods considered as an important economic pest worldwide. They infest plants causing severe damage to field crops, fruit orchards and vegetable crops, followed by considerable yield reduction (Baur and Baur, 1993). In Egypt, high populations of land snails, including *T. pisana*, reported in the Delta region (Ali and Robinson, 2020). They are widespread pests through transportation from infested regions by human activities (Desoky, 2018). The highest population recorded on soil around plants, under dead leaves, on stems and leaves of different plants (Awad, 2013).

Among land snails, *T. pisana*, poses a significant threat to agriculture worldwide (Odendaal *et al.,* 2008).They infest pastures and grain crops in the western Mediterranean and southern Australia (Baker, 1986) andin the Atlantic coast from Morocco to England (Yildirim *et al.,* 2004). In Egypt, *T. pisana*snail can be found invading economic crops under different environmental conditions. Recently, it became one of the major crop pests in many Egyptian Governorates; Qalubia, Sharkia, Gharbia, Munyfia, Dakahlia, Dumyat and Ismaelia (Mohammed, 2015). The seasonal activity of land snails is also influenced by environmental factors such as temperature and relative humidity. Research has indicated that snail populations tend to peak during spring when conditions are more favorable for their survival (Bayoumi *et al.,* 2024). Previous studies focused on the overall impact of land snails on agriculture, with limited research on their distribution behavior (i.e. horizontal and vertical spread) in citrus orchard.

Therefore, this study aims to investigate the spatial and temporal distribution of *T. pisana* snails, within citrus orchards, in relation to different citrus variety. By understanding the factors affecting snail population

distribution, we seek to provide valuable insights for developing effective pest management strategies for citrus growers.

MATERIALS AND METHODS

Study area:

This study was conducted in a citrus orchard at El-Mohamadia village, Minya El-Qamh district, Sharkia Governorate, Egypt (30º. 54' N and 31º. 31' E). This orchard is divided into three areas (1 faddan each) planted with different varieties of citrus (navel orange, *C sinensis*; balady mandarin, *C. deliciosa* and ponkan mandarin, *C reticulata*). The distance between trees is about four meters. The irrigation system in this orchard is flood irrigation. The snail (*T. pisana*) was identified according to (Godan, 1983; Ali &Ramadane, 2020).

1- Horizontal distribution:

Five trees of each citrus variety randomly selected and fixed at each reading.Around each selected tree, wooden squares 50 cm x 50 cm (Staikou *et al.,* 1990) were placed at distances of 0.5 m, 1 m, and 1.5 m from the trunk. The placement of the squares was randomized. The number of snails within each square was counted and left in initial places after that (Ismail *et al*., 2017). This procedure was conducted on first week of each month from November 2022 to October 2023.

2- Vertical distribution:

As mentioned previously the same trees, selectedfor the horizontal distribution study, were used. On the first week of each month from November 2022 to October 2023, each tree was divided into three height zones: 0-1 m, 1-2 m, and >2 m. The number of active and inactive snails in each zone was counted and left undisturbed in each place.

3- Statistical analysis:

The obtained data were subjected to one-way analysis of variance (ANOVA) using (Costat program, 2005). The Least Significant Difference (LSD) test was performed at a significance level of $p \leq 0.05$. Correlation coefficients were also calculated to analyze the relationship between snail numbers and different distances and levels in horizontal and vertical distribution.

RESULTS

The results showed that population of the *T. pisana* snail varies according to location during the months of the year from one variety to another such as follows:

1- Horizontal distribution:

Data in Table (1) showed that population density of *T. pisana* snail at different distances from tree trunks of different varieties of citrus trees during the growing season 2022-2023.

a- Distance and population density:

A clear inverse relationship exists between distance from the tree trunk and snails' population density. Across all varieties, the highest numbers of snail were 261.4, 147 and 95.2 snails observed at 0.5m for balady mandarin, navel orange and ponkan mandarin, respectively. By increasing the distance from tree trunk, the population density decreased until reach the lowest value 34.2 and 31.2 snails at 1.5m for balady mandarin and navel orange, respectively. However, Ponkan mandarin deviated from this trend, which it showed the lowest population density 23.2 snails at 1m compared to 0.5m and 1.5m (Table 1).

The statistical analysis showed a negative correlation confection between distances in horizontal distribution and population density in all varieties. However, this correlation differed between varieties, as the correlation was highly significant in the case of local mandarin and was significant in the case of navel orange. For the ponkan mandarin, the correlation confection was insignificant (Table 3).

b- Seasonal fluctuations:

Snail population densities fluctuated across all varieties throughout the months of the year. Balady mandarin and navel orange reached its peak densities, 87.2 and 74 snails, respectively in April, while ponkan mandarin reached its peak, 63 snails, in March. As for the remaining months, the population fluctuated up and down, and the lowest population densities, 2.6 and 1.2 snails, were during September, for both navel oranges and balady mandarin, respectively. For ponkan mandarin, no recorded snail observed during February, June, July, August and September of the same year (Table 1).

c- Varieties and snail population densities:

As shown in (Table 1 and Fig. 1), it was found that there was a significant difference in population density between balady mandarin and both navel orange and ponkan mandarin(P = 0.0035).However, no significant difference was observed between navel orange and ponkan mandarin. Balady mandarin consistently exhibited the highest population density (442 snails), followed by navel orange (253.2 snails). Ponkan mandarin had the lowest population density (160.2 snails) throughout the year.

Table 1. Population density of *T. pisana* snail at different distances from the tree trunk of various citrus varieties during the 2022-2023 growing season

Varieties	Level	Mean number of snails												Grand total	General mean
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Navel orange	0.5m	8	11	10	15	23	38	24	8	0	3	2	5	147	12.25
	1m	8	1	1.6	0	8	21	13	10	0	0	0.6	11.8	75	6.25
	1.5m	2	6	2.6	0	0	15	0	0	4	0	0	1.6	31.2	2.60
	Sum	18c	18c	14.2cd	15c	31b	74a	37b	18c	4de	3e	2.6e	18.4c	253.2	21.10
P value= .0018**LSD 0.05 = 10.49															
Balady mandarin	0.5m	11	11	18	31	52	48	36.2	28	18	6.2	0	2	261.4	21.78
	1m	5	8.4	14.8	15	31.6	37.2	15	11	4	٠.٨	0.6	3	146.4	12.20
	1.5m	11	18	0	0	1	2	0	0	0	0	0.6	1.6	34.2	2.85
	Sum	27de	37.4bcd	32.8cde	46bc	84.6a	87.2a	51.2b	39bcd	22ef	7fg	1.2g	6.6g	442	36.83
P value= .0000*** LSD 0.05 = 15.06															
Ponkan mandarin	0.5m	4	0	7.6	0	51	7	22	0	0	0	0	3.6	95.2	7.93
	1m	6	0	1.6	0	5	0	3	0	0	0	0	7.6	23.2	1.93
	1.5m	9	10	0	0	7	0	14	0	0	0	0	1.8	41.8	3.48
	Sum	19c	10d	9.2d	0e	63a	7de	39b	0e	0e	0e	0e	13cd	160.2	13.35
Pvalue= .0135*LSD 0.05 = 8.79															

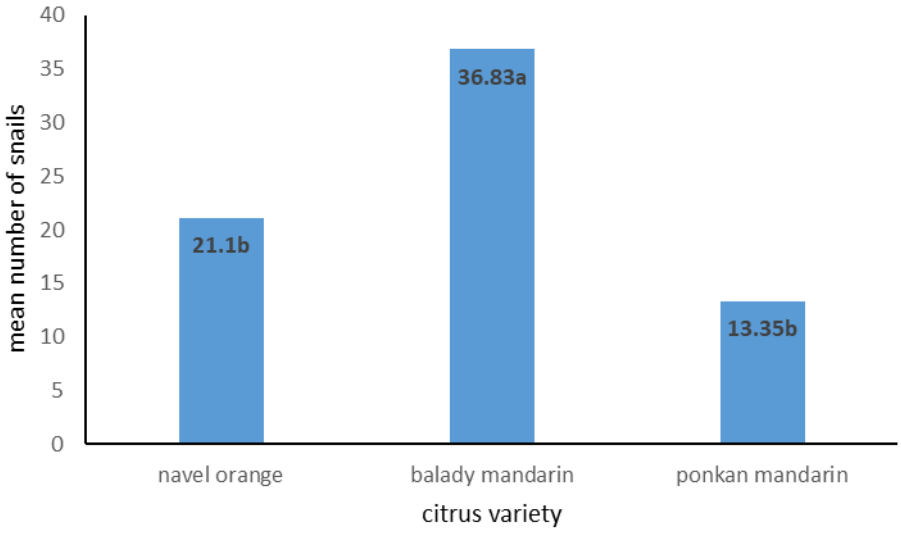

Fig. 1. Average total number of horizontally distributed *T. pisana* snails throughout the growing season 2022-2023 on the three citrus varieties

2- Vertical distribution:

Data in (Table 2) showed that population density of *T. pisana* snails, on different varieties of citrus trees, at the three levels, during the growing season 2022-2023.

a- Levels and population densities:

The second level (1-2 meters) was the highest in populations for all varieties. Total populations reached 271, 950.4 and 205.2 snails for navel orange, balady mandarin and ponkan mandarin, respectively. The population at the first level (0-1 meter) was average. As for the third level populations(above 2 meters), it was the lowest in, with the number of snails reached 38.4, 55.8 and 52.4 snails for navel orange, balady mandarin and ponkan mandarin, respectively (Table 2).

From Table (3), the statistical analysis showed a negative correlation confection between distances in vertical distribution and population densities for all three varieties.However, the correlation confection was not significant between the three highest population densities in all study variety.

b- Seasonal fluctuation:

Snail population densities varied significantly across months. It fluctuated up and down throughout the study, as they reached the highest levels of 432 and 134.6 snails in June, for balady mandarin and navel orange, respectively. While for the ponkan mandarin, its highest population of 115.2 snails was in August. Then the population values fluctuated increase and decrease during the remaining months until they reached their lowest populations, during December and February, for the three varieties. No snails were observed during this period, except for navel orange, where two individuals were found during December (Table 2).

c- Varieties and snail population densities:

As shown in (Table 2 and Fig. 2) it was found that a significant difference in population density between balady mandarin and both navel orange and ponkan mandarin(P <0.0001). However, no significant difference was observed between navel orange and ponkan mandarin. Balady mandarin recorded the highest population during the year (1643.2 snails per tree). The navel orange and ponkan mandarin had the lowest populations, as they recorded 537.6, 334.8 snails/ tree, respectively.

Table 2. Population density of *T. pisana* snails at different levels on various citrus varieties during 2022-2023 growing season.

Var.	Level	Mean number of snails												Grand total	General mean
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Navel orange	0- 1m	8.0	2	0.6	0	30.0	28.0	32.0	41.0	37.0	28.8	15.6	5.2	228.2	19.02
	1- 2m	2.0	0	0	0	3.0	4.6	15.0	81.6	80.0	51.2	18.0	15.6	271.0	22.58
	> 2m	0	0	0	0	0	0	1.0	12.0	9.0	6.0	2.8	7.6	38.4	3.20
	Sum	10e	2e	0.6e	0e	33d	32.6d	48c	134.6a	126a	86b	36.4cd	28.4d	537.6	44.80
	P value= .0000***										LSD 0.05 = 14.81				
Balady mandarin	0- 1m	11	0	0.6	0	9.0	26.0	35.0	120	150.0	244.8	31.0	9.6	637	53.08
	1- 2m	13	0	0	0	2.0	11.0	78.6	290	257.0	165.2	105	28.6	950.4	79.20
	> 2m	0	0	0	0	0	0	10.0	22	14.6	2.6	4.0	2.6	55.8	4.65
	Sum	24cd	0e	0.6e	0e	11de	37c	123.6b	432a	421.6a	412.6a	140b	40.8c	1643.2	136.93
	P value=.0000***										LSD 0.05 = 20.30				
Ponkan mandarin	0- 1m	10	0	4	0	0	5	٢٧.٦	0	1	13	7	10.6	78.2	6.52
	1- 2m	٤	0	0	0	2	2	19	30	35	77.2	23	12	204.2	17.02
	> 2m	0	0	0	0	5	0	3	5	4	25	4.6	5.8	52.4	4.37
	Sum	1٤d	0e	4de	0e	7de	7de	٤٩.٦b	35c	40bc	١١٥.٢a	34.6c	28.4c	334.8	27.90
	P value=.0008***										LSD 0.05 = 12.03				

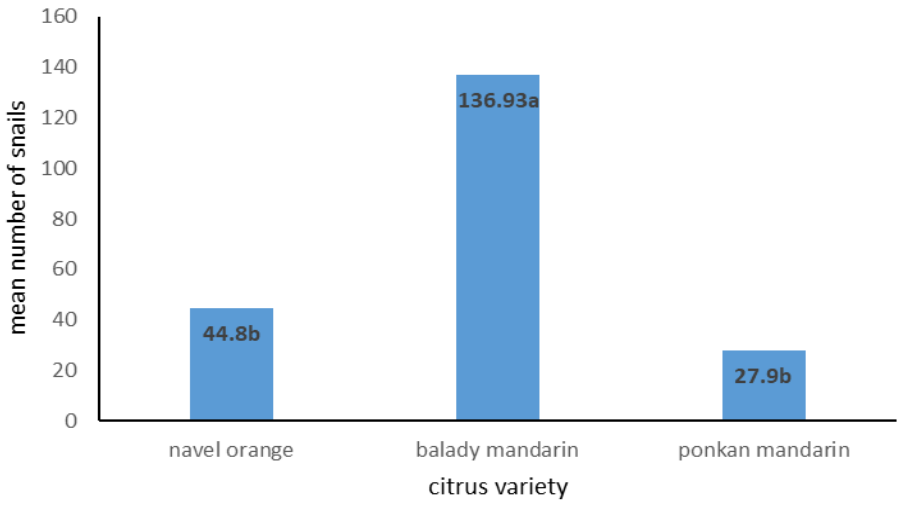

Fig. 2. Average total number of vertically distributed *T. pisana* snails throughout the growing season 2022-2023 in the three citrus varieties

Table 3. Correlation confection between the different distances and levels in the horizontal and vertical distribution and the population density of *T. pisana* snail during growing season 2022-2023

Varieties	Horizontal distribution		Vertical distribution	
	r	p-value	r	p-value
Navel orange	-0.46	.0049 **	-0.31	.0668 ns
Balady mandarin	-0.54	.0006 ***	-0.25	.1381 ns
Ponkan mandarin	-0.20	.2499 ns	-0.06	.7333 ns

P≤0.05, r: Simple correlation, ns: Non-significance, **Significant and ***Highly significant

DISCUSSION

Our findings revealed distinct patterns in horizontal and vertical population distributions, along with seasonal fluctuations in snail abundance across the three citrus varieties. In horizontal Distribution, Snail density exhibited an inverse relationship with distance from the tree trunk. Suggesting that snails favor the microclimate near the base of the tree, which typically offers higher humidity and protection from direct sunlight (Riddle, 1990). The observed spring peak populations for citrus variety also reflected favorable spring conditions for snail activities and reproduction. The smallest number of snails in the summer, for all varieties, happens because of the hot and dry weather. This kind of weather makes snails go into aestivation. Notably, Balady mandarin consistently supported the highest overall snail population density, suggesting a potential preference for its microclimate or foliage density and variety characteristics. In respect to vertical Distribution, Snail prefer the middle canopy zone (1- 2 meters) as this zone offers a balance between moisture availability and protection from predators. The reduced densities observed in the upper canopy are likely due to greater exposure to sunlight and desiccation. Interestingly, the peak populations occurred during summer months across all varieties. This seemingly contradictory finding might be explained by the snails seeking refuge within the canopy from the harshest summer temperatures, despite the potential for increased desiccation (Cowie, 1990; Staikou, 1999). In addition, balady mandarin consistently supported the highest overall snail population density compared to navel orange and ponkan mandarin, which have less vegetation than the balady mandarin.

Comparison with Previous Research: Our findings are consistent with several previous studies that have documented variations in snail populations across different host plants and seasons. For instance, (Heikal, 2015) reported significant differences in monthly snail numbers (*Monachacartusiana, T. pisana*, and *Eobaniavermiculata*) infesting orange, apple, and grape trees. Similarly, (Abdel Kader *et al*., 2016) observed peak *Cochlicella acuta* populations during summer months. While, the lowest values of population density were detected during January and February. Ismail *et al.* (2017) *on E. vermiculata*, (Khidr *et al.,*2020) on *T. pisana*have observed a decrease in population density with increasing distance from the tree trunk (horizontally) and increasing height (vertically) on navel orange trees, with spring harboring the highest densities. Other studies, such as (Ibrahim *et al.,* 2021) on *Monachaobstructa*, (Abd-Elhaleim *et al*., 2022) on *T. pisana* have also reported seasonal fluctuations in snail populations, with spring peaks often coinciding with favorable environmental conditions.

CONCLUSION

Our results showed that snail numbers gathered near tree trunks, therefore, instead of applying control materials on a large scale throughout the orchard, control can be concentrated on the areas around the tree trunk. This will reduce both control costs and environmental pollution. For all varieties, snails prefer the middle area of 1-2m, therefore control methods should be focused on this area. Snail peak populations occurred during spring months, for horizontal distribution, and during summer months, for vertical distribution. Therefore, it is recommended to carry out the control process during winter months, before snail reproduction process and before the snail populations reached their peaks. Balady mandarin is the most susceptible citrus variety to *T. pisana* infestation that information should enables growers to prioritize monitoring and controlling efforts on this specific variety.

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التغيرات الموسمية في وفرة وتوزيع قوقع *Theba pisana* (مولر) على أصناف مختلفة من الحمضيات في محافظة الشرقية، مصر

محمد عابد* ,محمد عبدالله عيسي و محمد إبراهيم البخشونجي

معهد بحوث وقاية النبات، مركز البحوث الزراعية، الدقي، جيزة، مصر

* بريد المؤلف المراسل: drmohamadabed85@gmail.com

تناولت هذه الدراسة ديناميكيات التعداد الموسمية (التوزيع الأفقي والرأسي) لقوقع *Theba pisana* (مولر) تحت الظروف الحقلية لثلاثة أصناف من الموالح في محافظة الشرقية، مصر، خلال موسم النمو 2022-2023. درس البحث أنماط التوزيع الأفقي (0.5 ، 1 ، 1.5 متر من جذع الشجرة) والرأسي (0-1 ، 1-2 ، >2 متر) على البرتقال أبوسرة (*Citrus sinensis*) واليوسفي البلدي (*Citrus deliciosa*) واليوسفي الصيني (*Citrus reticulata*). أظهر تحليل التوزيع الأفقي وجود علاقة عكسية بين المسافة من جذع الشجرة وكثافة القوقع عبر جميع الأصناف، حيث تم تسجيل أعلى عدد من تعداد القوقع عند 0.5 متر يليه 1 متر. وكان أقل عدد من تعداد القوقع على مسافة 1.5 متر من جذع الشجرة. بلغت ذروة التعداد خلال اشهر الربيع (مارس-مايو) لليوسفي البلدي والبرتقال أبوسرة وفي شهر مارس لليوسفي الصيني. أظهرت جميع الأصناف اقل تعداد خلال أشهر الصيف (يوليو-سبتمبر). فيما يتعلق بالتوزيع الرأسي، أظهرت جميع الأصناف تفضيلًا واضحًا للمنطقة الوسطى (1-2 متر)، تليها المنطقة السفلية (0-1 متر)، بينما لوحظ أدنى كثافة للقواقع في المنطقة العلوية (>2 متر). بلغت التذبذبات الموسمية في تعداد القواقع ذروتها خلال أشهر الصيف (يونيو-أغسطس)، بينما أقل تعداد كان خلال فصل الشتاء. وجد فرق معنوي في كثافة التعداد لـ (التوزيع الأفقي والرأسي) بين اليوسفي البلدي وكلا من البرتقال أبوسرة واليوسفي الصيني. ومع ذلك، لم يُلاحظ أي فروق معنوي بين البرتقال أبوسرة واليوسفي الصيني. سجل اليوسفي البلدي أعلى كثافة إجمالية للتعدادثم البرتقال أبوسرة واليوسفي الصيني.

الكلمات المفتاحية: *Theba pisana* ، أصناف الحمضيات، التوزيع الأفقي والرأسي