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Research Article

Biological aspects and population dynamics of three terrestrial snails infesting fruit trees in Egypt

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Abstract

Laboratory and field experiments were conducted to study some biological aspects and the seasonal fluctuation of three economic land snails infesting three fruit crops along two successive years at the experimental laboratory and private orchards of Shebin El-Kom center - Menoufia governorate. The obtained results indicated that there were significant differences in the biological aspects among the three land snails, *Monacha cartusiana*, *Theba pisana*, and *Eobania vermiculata* under laboratory conditions, where the longest mean life cycles were 379.4 ± 15.2 and 364.0 ± 14.1 for *E. vermiculata*, *M. cartusiana* without significant differences between them, while the difference was significant with *T. pisana* 313.3 ± 10.2 (LSD 5% = 37.5). As for the ecological studies on the land snails under field conditions, the statistical analysis of the obtained results indicated that there were significant differences among the monthly numbers of each snail species infesting orange, apple and grape trees along the two years of study, furthermore, there were significant differences among the grand total numbers of each snail infesting the three fruit crops. The results of the two years concluded that the highest occurrence of snail species was recorded with the snail *E. vermiculata* (39.7%), as well as the highest infested crop was orange, while the lowest numbers were recorded with the *T. pisana* snail (28.5%), and grape crop. It could be concluded that the optimum period for good control of land snails are in Autumn months where the population was very low as well as the snails are active.

Keywords: land snails, biological aspects, *Monacha cartusiana, Theba pisana, Eobania vermiculata*, and population dynamics.

Introduction

The terrestrial mollusca which including snails and slugs are destructive agricultural pests causing economic damage to a wide variety of plants including horticultural and field crops. Land snails cause heavy damage, through eating leaves, roots and fruits, as well as damage was observed on the trunk of the trees and ornamental plants (El-Deeb *et al*., 1999). Snails cause economic damages to the leaves and fruits, which was observed on trunk crops and ornamental plants, as well as apple, citrus, peach, palm and vegetables, i.e. cabbage, carrot and bean (Dekle, 1969).

Biological aspects of the land snails have been studied by many researches Kassab and Daoud (1964), who reported that the life cycle of *Helicella vestalis* was relatively simple, eggs was laid in clutches, each contained from 25 to 30 eggs in the soft soil and were deposited in small cavities or holes in the hard soil, at any time during Spring season. In Australia, Baker (1986) found that *Theba pisana* snail laid eggs in the soil at 3-4 cm deep holes, and sealed the hole with mixture of slime and soil, and added that each pair of snails laid up to five clutches; each snail laid about 120 eggs in a season. Furthermore, Sacchi (1990) studied the biotic cycle of *Theba pisana* and found that it might be either annual or biennial, depending on regional and local climatic factors. In countries where the biotic cycle of the snail was annual, low Winter temperatures play a major role, while a mild Summer ensured active development and reproduction. In addition to others conducted by Al-Attar (1994), El-Deeb *et al*. (1997), Abd El-All (2001) and Genena (2003).

Several studies were carried out on the survey of land snails in Egypt i.e. El-Okda (1984), Awad (1994), and Shoieb (2008).

The majority of studies which have been carried out on the ecology of the Egyptian land snails included El-Okda (1981), Ghamry *et al*. (1993), Hashem *et al*. (1993), El-Deeb *et al*. (1996, 1998, 1999, 2004), Awad (2000), and Ismail et al. (2003).

From the previous view, the aim of this study is to study some biological aspects and the population dynamics of three land snails: *Monacha cartusiana, Theba pisana,* and *Eobania vermiculata*.

Materials and Methods

Laboratory and field experiments were conducted to study some biological aspects and the monthly fluctuation of three economic land snails, the glassy clover snail, *Monacha cartusiana*, the small garden snail, *Theba pisana*, the brown garden snail, *Eobania vermiculata*, infesting three fruit crops along two successive years at the experimental laboratory and at Shebin El-Kom center of Menoufia governorates.

Biological Experiments:

The main biological aspects of three land snail species were conducted under laboratory conditions of 22 ± 2 ºC and 55 ± 5 % RH.

The snail species: *Monacha cartusiana, Theba pisana,* and *Eobania vermiculata* were reared to determine some biological aspects i.e. incubation period, juvenile period, pre-oviposition period, life cycle, number of eggs /clutch, hatching period. Snails were collected and reared in the laboratory, where adult snails of each species were transferred to glass containers (70 X 40 X 40 cm) which contained loamy soil. Six containers were used for each snail as replicates, ten pairs of each snail species was transferred in each container. Snails were fed twice daily on fresh washed leaves of lettuce or cabbage. The soil was remoistened by water as required; in addition the remained diet was removed every two days. Containers were covered with muslin and secured with rubber band to prevent snails from escaping. Hatching period, number of eggs, life cycle, pre-oviposition period, juvenile period, and incubation period were calculated for each snail. The soil within each box was searched for clusters of eggs. Eggs were observed daily to calculate percent of hatching and incubation period.

Ecological experiments:

Monthly snail samples were collected at early morning from three fruit crops: Orange, *Citrus sinensis* variety Naval, Apple, *Malus domestica* variety Balady, and Grape *Vitis vinifera* variety Seedless. Thirty trees of each fruit crop were chosen and divided to three replicate, where each one consists of ten trees. One meter around each tree was examined, and snails were collected in clothes bags according to the method of (Staikou and Lazaridou-Dimitriabou 1990), and transferred to the laboratory for examination and counting and identification according to the systemic keys given by Godan (1983) and El-Okda (1984).

Experiments were continued along two successive years from 21 of September 2010 to 21 of August 2012.

Statistical analysis

Data were analyzed by the computer using the CoStat 6.400 (2008) Statistical CoHort Software program, Copyright © 1998- 2008 CoHort Software 798 Lighthouse Ave. PMB 320 Monterey CA, 93940 USA, using ANOVA test with LSD 5% and the Mean ± SE.

Results and Discussion

Biological studies on three land snails:

Results in Table (1) show the biological aspects of the three land snails, *Monacha cartusiana, Theba pisana,* and *Eobania vermiculata* under laboratory conditions (22 ± 2 ºC and 55 ± 5 % RH).

Statistical analysis of the obtained results indicated that there were significant differences in the mean values of the biological aspects periods among the three snail species under investigations except the hatching period.

The obtained results Table (1) indicated that the longest mean life cycle was 379.4 ± 15.2 days and 364.0 ± 14.1 for *E. vermiculata* and *M. cartusiana* without significant differences between them, while the difference was significant with *T. pisana* 313.3 ± 10.2 days (LSD 5% = 37.5).

Table (1): Some biological aspects of three land snails under laboratory conditions (22 ± 2 ºC and 55 ± 5 % RH)

Character	*Monacha cartusiana*	*Theba pisana*	*Eobania vermiculata*	LSD 5%
	Mean values ± SE			
Incubation period (day)	19.3 ± 1.6 a	16.3 ± 2.1 b	12.0 ± 1.0 c	2.3
Juvenile period (day)	112.0 ± 4.2 b	96.0 ± 3.2 c	117.6 ± 4.5 a	10.6
Pre-oviposition period (day)	232.7 ± 4.8 b	201 ± 3.8 c	249.8 ± 5.9 a	25.6
Life cycle (day)	364.0 ± 14.1 a	313.3 ± 10.2 b	379.4 ± 15.2 a	37.5
Number of eggs /clutch	35.0 ± 1.5 a	25.0 ± 1.2 c	30.0 ± 1.4 b	3.8
Hatching period (day)	18.0 ± 2.0 a	19.0 ± 2.0 a	17.0 ± 2.0 a	2.5

Means in the same row followed by the same letter are not significantly different

Ecological studies on land snails infesting fruit crops

The monthly dynamics of three land snails, the glassy clover snail, *Monacha cartusiana*, the small garden snail, *Theba pisana*, and the brown garden snail, *Eobania vermiculata*, infested Seedless orange, Balady apple, and Seedless grape were studied at three orchards of Shebin El-Kom locality, for two successive years.

Statistical analysis of the obtained data (Tables 2, 3, 4) indicated that there were significant differences in the monthly numbers of each snail species infesting orange, apple and grape trees along the two years of study, furthermore, there were significant differences among the grand total numbers of each snail infesting the three fruit crops.

Monacha cartusiana

Results in Table (2) and depicted in Fig. (1) show the monthly fluctuation of *M. cartusiana* for one year from September 2010 to August 2011 indicated that the monthly population numbers of *M. cartusiana* were varied from month to other and from crop to other, where the highest number of snail infested orange trees was registered at August month giving 66 individuals per 10 trees (LSD 5%= 5.9), while the lowest monthly number was recorded at Autumn and Winter months (September to February) ranged between 26 to 30 individuals per 10 trees without significant differences (LSD 5%=5.9).

Regarding to *M. cartusiana* infesting apple trees, the highest monthly number of snail was recorded at Spring months specially at April and May months 60, 63 individuals per 10 trees (LSD 5%= 6.8), respectively, without significant differences between them, while the lowest number of snail was recorded at Autumn months (September, October, November) giving 18 to 22 individuals per 10 trees (LSD 5%= 6.8), without significant differences among them.

Table (2): Monthly fluctuation of *M. cartusiana* land snail infesting three fruit crops at Shebin El-Kom locality, Menoufia governorate from Sept. 2010 to Aug. 2012.

Months 1 st year	Average numbers of *Monacha cartusiana* / 10 trees							Grand Total
	orange	apple	grape	Months 2 nd year	orange	apple	grape	
Sep.2010	28 fg	20 d	29 g	Sep.2011	55 a	25 g	30 de	187
Oct.	27 g	18 d	23 h	Oct.	43 b	20 g	29 e	160
Nov.	29 fg	22 d	42 f	Nov.	23 g	22 g	30 de	168
Total	84	60	94	Total	121	67	89	515
Dec.	30 fg	31 c	42 f	Dec.	25 fg	39 f	35cde	232
Jan.2011	33 d	33 c	47 e	Jan.2012	27efg	42 ef	36cde	218
Feb.	26 g	35 c	49 de	Feb.	31def	46def	35cde	222
Total	89	99	138	Total	83	127	106	672
Mar.	36 de	45 b	53 d	Mar.	33cde	49cde	49 b	265
Apr.	41 cd	60 a	68 b	Apr.	37bcd	56abc	50 b	312
May	43 c	63 a	96 a	May	42 b	63 a	65 a	372
Total	120	168	217	Total	112	168	164	949
Jun.	46 bc	45 b	62 c	Jun.	36 bcd	52bcd	34cde	285
Jul.	51 b	47 b	65 bc	Jul.	39 bc	57 ab	37cd	296
Aug.	66 a	51 b	68 b	Aug.	41 b	63 a	39 c	328
Total	163	143	195	Total	116	172	110	909
Grand total	456 B	470 B	644 A	Grand total	432 C	534 A	469 B	
LSD 5%	5.9	6.8	4.6	LSD 5%	7.2	7.7	7.1	

Means followed by the same letter in the same column are not significantly different

Regarding to *M. cartusiana* infesting grape trees, the highest monthly numbers of snail was recorded at Spring specially at May month, 2011 giving 96 individuals per 10 trees (LSD 5% = 4.6) , while the lowest numbers of snail were recorded at Autumn months (September, and October,2011) giving 29, 23 individuals per 10 trees (LSD 5% = 4.6), respectively, with significant differences between them.

As for the monthly numbers of *M. cartusiana* snail infested orange, apple and grape trees during the second year of experiments (September 2011 to August 2012) Table (2) it could be concluded that the obtained results confirmed that of the first year.

Regarding to the highest grand total numbers of *M. cartusiana* snail during the first year of investigation, the highest numbers were recorded with grape trees recording 644 snails followed by that infested apple 470 and orange 456 without significant differences among them.

As for the second year, the highest grand total numbers were recorded with apple trees recording 534 snails followed by that infested grape 469 and orange 432 with significant differences among them.

Theba pisana

Results in Table (3) and depicted in Fig. (2) show the monthly fluctuation of the white garden snail, *Theba pisana* for two years from September 2010 to August 2012. Data indicated that the monthly population numbers of *T. pisana* were varied from month to other and from crop to other, where the highest number of snail was recorded at May month (161 individuals /10 trees) infested apple trees (LSD 5% = 6.0), while the lowest monthly numbers were recorded at Autumn months (September and October) 9 and 10 individuals /10 trees without significant differences.

Regarding to *T. pisana* infesting orange trees, the highest monthly numbers of snail was recorded at Spring months specially at April and May months 62, 65 individuals /10 trees (LSD 5% = 5.4), respectively, without significant differences between them, while the lowest numbers of snail were recorded at Autumn months (September, October, and November) giving 30 to 32 individuals /10 trees (LSD 5% = 5.4), without significant differences among them.

Table (3): Monthly fluctuation of *Theba pisana* land snails infesting three fruit crops at Shebin El-Kom locality, Menoufia governorate from Sept. 2010 to Aug. 2012

Months 1st year	Average numbers of *Theba pisana* / 10 trees							
	orange	apple	grape	Months 2nd year	orange	apple	grape	Grand total
Sep.2010	30 e	10 fg	43 f	Sep.2011	31ef	12 f	23 fg	149
Oct.	32 de	9 g	35 g	Oct.	30 f	18 e	20 fg	144
Nov.	32 de	16 f	49 ef	Nov.	31 ef	20 e	19 g	167
Total	94	35	127	Total	92	50	62	460
Dec.	33 de	41cd	50 ef	Dec.	33 ef	19 e	21efg	197
Jan.2011	35 de	43cd	55 ef	Jan.2012	35 de	22 e	24 ef	214
Feb.	41 c	46 c	59 d	Feb.	38 d	29 d	29 cd	242
Total	109	130	164	Total	106	70	74	653
Mar.	47 b	53 b	69 c	Mar.	46 c	32cd	32bc	279
Apr.	62 a	57 b	77 b	Apr.	52 b	37ab	36 b	321
May	65 a	161a	93 a	May	63 a	40 a	41a	463
Total	174	271	239	Total	161	109	109	1063
Jun.	37 cd	34 e	15 h	Jun.	19 h	32cd	19 g	156
Jul.	41c	38de	17 h	Jul.	22 gh	33bcd	22efg	180
Aug.	42 bc	42cd	20 h	Aug.	25 g	34bc	25 de	335
Total	120	114	52	Total	66	99	66	671
Grand total	497 C	550 B	582 A	Grand total	425 A	328 B	311 B	
LSD 5%	5.4	6.0	7.4	LSD 5%	4.4	4.9	4.3	

Means followed by the same letter in the same column are not significantly different

Regarding to *T. pisana* infesting grape trees, the highest monthly numbers of snail was recorded at Spring specially at May month giving 93 individuals /10 trees (LSD 5% = 7.4), while the lowest numbers of snail were recorded at Summer months (June, July, and August) giving 15,17,20 individuals /10 trees (LSD 5% = 7.4), respectively, without significant differences between them.

As for the monthly numbers of *T. pisana* snail infested orange, apple and grape trees during the second years of experiments (September 2011 to August 2012) Table (3) it could be concluded that the obtained results confirmed that of the first year.

Regarding to the highest grand total numbers of *T. pisana* snail during the first year of investigation, the highest numbers were recorded on grape trees recording 582 snails followed by that infested apple 550 and orange 497 with significant differences among them. As for the second year, the highest grand total numbers were recorded with orange trees recording 425 snails followed by that infested apple 328and grape 311 with significant differences.

Eobania vermiculata

Results in Table (4) and depicted in Fig. (3) show the monthly fluctuation of *Eobania vermiculata* for two years from September 2010 to August 2012. Data indicated that the monthly population numbers of *E. vermiculata* were varied from month to other and from crop to other, where the highest number of snail infested orange trees was registered at April month giving 172 individuals /10 trees (LSD 5% = 6.4), while the lowest monthly numbers were recorded at Autumn, Winter and Summer months, where the mean numbers of the snail were ranged between 52 to 69 individuals /10 trees without significant differences (LSD 5% = 6.4).

Table (4) Seasonal fluctuation of *E. vermiculata* land snails infesting three fruit crops at Shebin El-Kom locality, Menoufia governorate from Sept. 2010 to Aug. 2012.

Months 1st year	Average numbers of *Eobania vermiculata* / 10 trees							
	orange	apple	grape	Months 2nd year	orange	apple	grape	Grand total
Sep.2010	52 f	11 f	35 ef	Sep.2011	62 bc	25 fg	35 cd	220
Oct.	69 bc	9 f	30 f	Oct.	52 de	18 h	32de	210
Nov.	54 ef	17 f	41cde	Nov.	42 g	26 fg	32de	212
Total	175	37	106	Total	156	69	99	642
Dec.	55 ef	72 d	46 cd	Dec.	44 fg	36 e	27 e	280
Jan.2011	59 de	75 d	50 c	Jan.2012	49 ef	39de	31de	303
Feb.	63 de	79 d	49 c	Feb.	65 b	43cd	36 cd	335
Total	177	226	145	Total	158	118	94	910
Mar.	68 bc	186a	65 b	Mar.	72 a	45 c	42 b	468
Apr.	172a	129c	72 b	Apr.	51 e	52 b	48 a	524
May	73 b	154b	89 a	May	58 cd	63 a	51a	488
Total	313	469	226	Total	181	160	141	1490
Jun.	53 ef	46 e	33 ef	Jun.	31 h	22gh	36 cd	221
Jul.	52 f	49 e	37def	Jul.	33 h	25fg	38 bc	234
Aug.	56 ef	51 e	41cde	Aug.	35 h	28 f	48a	259
Total	161	146	111	Total	99	75	122	714
Grand total	826 B	878 A	588 C	Grand total	594 A	422 C	456 B	
LSD 5%	6.4	11.8	9.6	LSD 5%	6.4	5.7	5.8	

Means followed by the same letter in the same row are not significantly different

Regarding to *E. vermiculata* infesting apple trees, the highest monthly numbers of snail was recorded at Spring months at March, April and May months 186, 129, 154 individuals /10 trees, respectively with significant differences among them (LSD 5% = 11.8), while the lowest numbers of snail were recorded at Autumn months (September, October, and November) giving 9 to 17 individuals /10 trees (LSD 5% = 11.8), without significant differences among them.

Regarding to *E. vermiculata* infesting grape trees, the highest monthly numbers of snail was recorded at Spring months specially at May month giving 89 individuals /10 trees (LSD 5% = 9.6), while the lowest numbers of snail were recorded at Autumn and Summer months (September, October, June, and July) ranging between 30 to 37 individuals /10 trees (LSD 5% = 9.6) respectively, with significant differences between them. As for the monthly numbers of *E. vermiculata* snail infested orange, apple and grape trees during the second year of experiments (September 2011 to August 2012) Table (4) it could be concluded that the obtained results confirmed that of the first year. As shown in Table (4) the highest grand total numbers of *E. vermiculata* snail was recorded during the first year of investigation, recording 2292 individuals comparing with 1472 at the second year. Furthermore, the highest numbers of snail were recorded with orange trees recording 1420 snails followed by that infested apple 1300 and grape 1044 with significant differences among them. Finally, from the results of the two years Table (5), it could be concluded that the highest occurrence of snail species was recorded with the snail *E. vermiculata* (39.7%), as well as the highest infested crop was orange, while the lowest numbers were recorded with the *T. pisana* snail (28.5%) and grape crop. As shown in Figs (1, 2, 3) it could be observed that the highest snail occurrence was recorded at Spring months (March, April, and May) specially May month, while the least numbers were recorded during Summer and Autumn months specially October and November

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Table (5) Occurrence percentages of the three snails infesting the surveyed fruit crops along two successive years

Year	*Monacha cartusiana*			*Theba pisana*			*Eobania vermiculata*			Grand total
	Average numbers of snails / 10 trees									
	orange	apple	grape	orange	apple	grape	orange	apple	grape	
2011/2012	456	470	644	497	550	582	826	878	588	5491
2012/2013	432	534	469	425	328	311	594	422	456	3971
Total	888	1004	1113	922	878	893	1420	1300	1044	9462
Grand total	3005			2693			3764			
% crop	29.6	33.4	37.0	34.3	32.6	33.1	37.7	34.6	27.7	
% snail	31.8			28.5			39.7			

In addition, Figs (1, 2, 3) revealed that the tested snails have one or two peaks per year at Spring months, where the suitable environmental factors are present, therefore, it could be recommend that the time of application must be arranged according to the seasonal fluctuation of these pests, where it can be controlled with food bait traps at Spring months, and applied different molluscicides at Summer and Winter months.

The obtained results on the biological aspects of the three land snails under investigation were in harmony with those obtained by Kassab and Daoud (1964), Cowie, (1984) and Sacchi (1990) and Hashem et al. (1992).Moreover, Cowie (1985) stated that the small garden snail, *Theba pisana* in Britain and France have an annual life cycle and breed in Summer and Autumn, while in the Mediterranean, it have a biennial life cycle with breeding in Autumn and Winter.

Furthermore, the obtained results on the ecology of examined snails are in agreement with those obtained by Ghamry *et al*. (1993), Hashem *et al*. (1993), El-Deeb *et al*. (1996), El-Deeb *et. al.* (1999) and Hegab *et al*. (1999) who reported that the highest population density of land snails infesting fruit crops were observed during Spring months due to the suitable climatic conditions during these periods compared with other months.

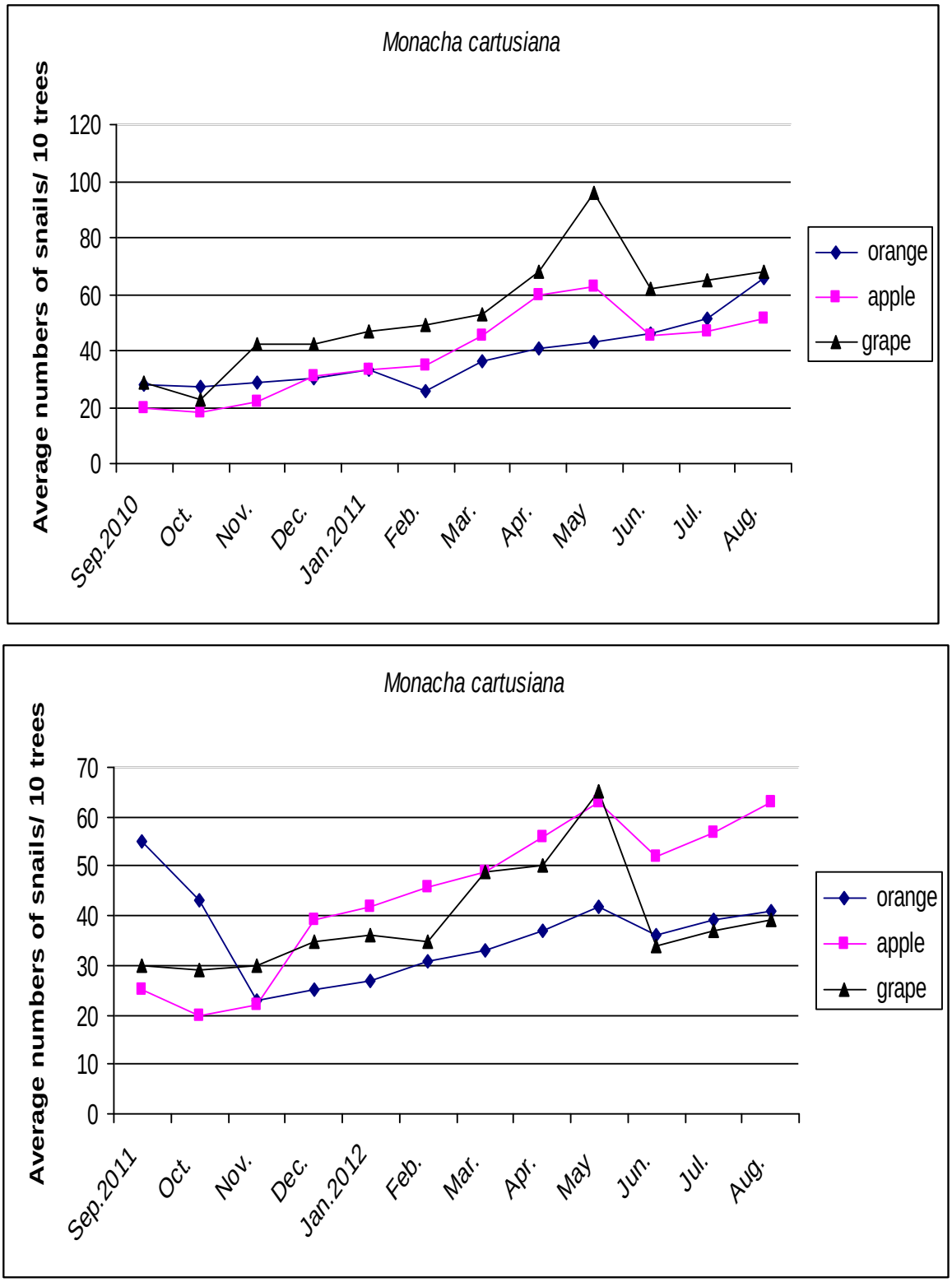

Fig (1): The monthly population dynamics of *M. cartusiana* snail infesting three fruit crops along two successive years.

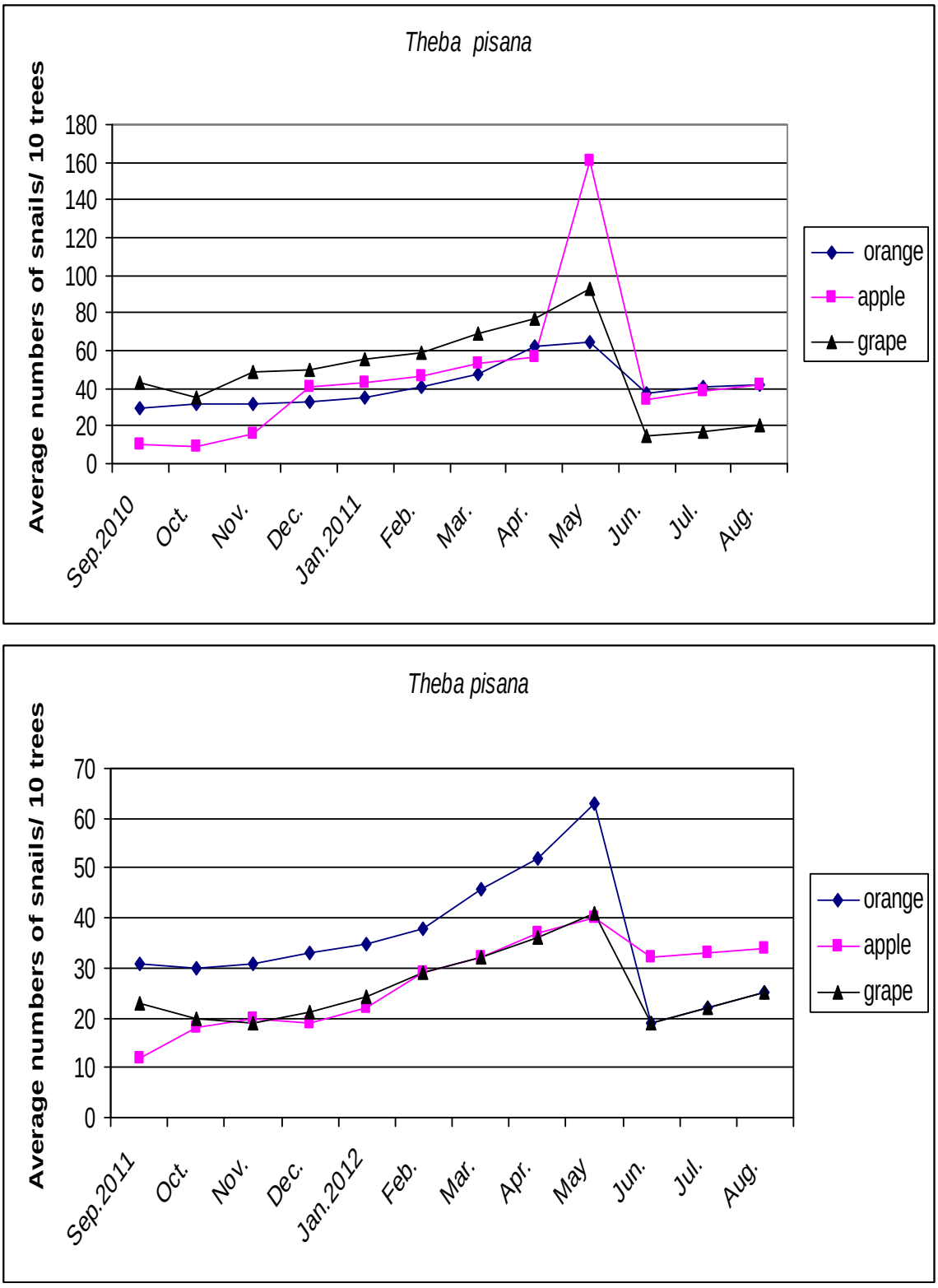

Fig (2): The monthly population dynamics of *T. pisana* snail infesting three fruit crops along two successive years.

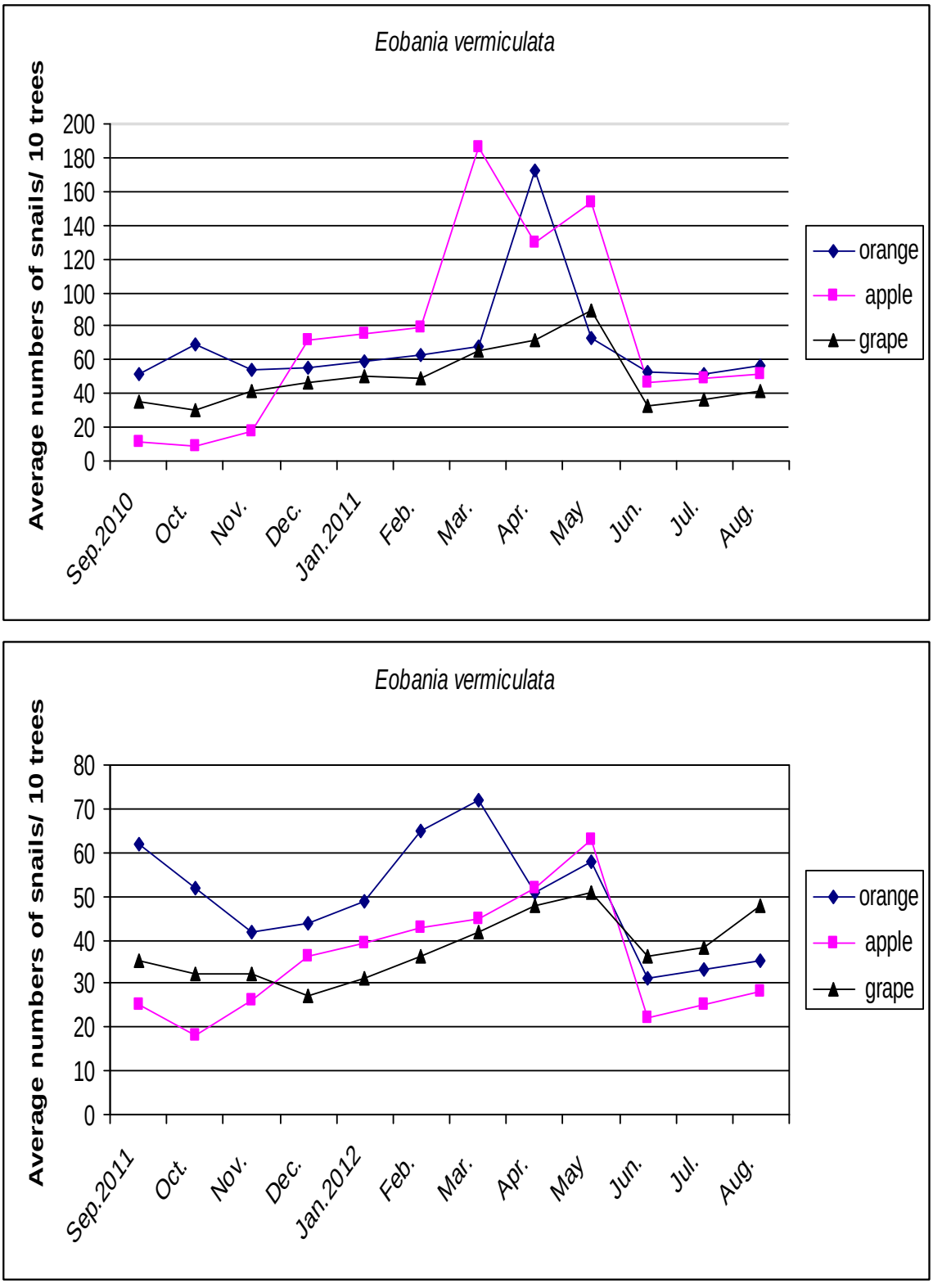

Fig (3): The monthly population dynamics of *E. vermiculata* snail infesting three fruit crops along two successive years.

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