Alinteri J. of Agr. Sci. (2018) 33(2): 183-192
e-ISSN: 2587-2249
info@alinteridergisi.com

http://dergipark.gov.tr/alinterizbd
http://www.alinteridergisi.com/
DOI: 10.28955/alinterizbd.427314

Alinteri Journal of Agriculture Sciences

RESEARCH ARTICLE

Weight and Length Relationships (WLRs) and Meat Yield of Brown Garden Snail, *Helix aspersum* Müller, 1774 and Turkish Snail, *Helix lucorum* Linnaeus, 1758 (Mollusca: Gastropoda: Helicidae) in the Sinop Province, Turkey

Hünkar Avni Duyar[1*], Özlem Bilgin[2] , Sabri Bilgin[1]

[1] *Sinop University, Faculty of Fisheries and Aquaculture, Department of Fisheries and Seafood Processing Tecnology, Sinop/Turkey.*
[2] *Sinop University Scientific and Technological Researches Application and Research Center (SUBITAM), Sinop/Turkey*

ARTICLE INFO

Article History:

Received: 25/05/2018

Accepted: 04.10.2018

Keywords:

Terrestrial snails
Helix aspersa
Helix lucorum
Weight and length relationships
Meat yield

ABSTRACT

The present work carried out on the length – weight relationship of two commercially important mollusks *Helix aspersa* and *Helix lucorum* were analyzed from Sinop province in the Central Black Sea region climate, Turkey. Totally 86 specimens of *H. aspersa* and 67 specimens of *H. lucorum* were collected for this study in 5 April 2018. Parameters of the shell length and weight (W) relationship by using the formula $W = aL^b$. The weight – shell height, weight – shell width and shell height - shell width results suggested that two helix species (*H. aspersa* and *H. lucorum*) showed negative growth characteristics ($b<3$, $P<0.05$). The shell height and shell width of *H. lucorum* was significantly ($P<0.05$) greater than the mean shell height and shell width of *H. aspersa*. The mean meat yield of *H. lucorum* was significantly (t-test, $P<0.001$) lower than the mean meat yield of *H. aspersa*. The present study can be use for future researches for cooperation to their results.

Please cite this paper as follows:

Duyar, H.A., Bilgin, Ö. and Bilgin, S. (2018). Weight and Length Relationships (WLRs) and Meat Yield of Brown Garden Snail, *Helix aspersum* Müller, 1774 and Turkish Snail, *Helix lucorum* Linnaeus, 1758 (Mollusca: Gastropoda: Helicidae) in the Sinop Province, Turkey. *Alinteri Journal of Agriculture Sciences*, 33(2): 183-192. doi: 10.28955/alinterizbd.427314

Introduction

Species of the genus Helix are the largest terrestrial snails distributed throughout the western Palaearctic region (Mumladze et al., 2008). The genus has economic importance since some species such as *Helix lucorum* Linnaeus, 1758 and *Helix aspersa* (Müller, 1774) are used as food in many countries (Yıldırım et al., 2004; Duman, 2015).

The brown garden snail, *H. aspersa*, is a terrestrial gastropod mollusk and one of the best known species in the world (Capinera, 2001). Turkish snail, *H. lucorum*, is a large,

* Corresponding author
E-mail address: had52@gmail.com (H. A. Duyar)

edible air breathing land snail or escargot, a terrestrial pulmonate gastropod mollusc in the family helicidae (Capinera, 2001; Nordsieck, 2018). As its name suggests, it originates from the Black Sea region, adjacent Asia Minor, today's western and central Turkey (Yıldırım et al., 2004). Now it is also found on the central Balkan Peninsula including southern Romania, Bulgaria and Thrace as far as Albania and Italy west of the Apennine (Yıldırım et al., 2004). The species has been introduced in Austria, south of Vienna; it has also been introduced in parts of Southern France, the Netherland and also in the Slovak Republic (Reinink, 2005; Mienis and Rittner, 2010; Čejka and Čačaný, 2014). With a shell diameter of between 30 and 60 mm the Turkish snail is usually larger than the *H. aspersa*, the form of a *H. lucorum* shell is similar to that of *H. pomatia*, globular with a depressed spire and largely rounded red brown strips going around the whorls (Nordsieck, 2018). Conchological differences between snails *H. pomatia* and European populations of *H. lucorum* was exhaustively described by Čejka and Čačaný (2014).

The brown garden snail is native to the Mediterranean region but now is in many more areas of the world, which makes it a species of wide distribution and presence on all continents, except Antarctica. Individuals of *H. aspersa* dwell in the lowlands of Great Britain, in the Mediterranean, in Western Europe, in North Africa including Egypt, in the Iberian Peninsula and the Middle East, including Turkey (Capinera, 2001). This species arrived at these places either accidentally hidden in plants or vegetable shipments or intentionally introduced for some purpose (Burch, 1960; Capinera, 2001). The *H. aspersa* individuals have the shell of the same color; some have it dark brown, but the majority has it light brown or with a golden hue; also, it shows several brown or yellow stripes and the shell has a large opening whose edges are white (Burch, 1960; Capinera, 2001). The *H. aspersa* is herbivorous and consumes many types of plant matter. It finds its food in fruit trees, herbs, cereals, flowers and bark of trees, but occasionally it adds to its diet organic matter in decomposition, either vegetable or animal (Duman, 2015). Some of these snails hibernate during winter months, especially when they are mature, but they return to activity with the spring (Capinera, 2001; Duman, 2015).

Terrestrial gastropods such as *H. lucorum* and *H. aspersa* play an important role in the ecology of the moist forests floor and they provide food for a variety of soil arthropods and small mammals (Digweed, 1993; Yıldırım et al., 2004). Terrestrial gastropods also play a role in litter decomposition and nutrient cycling of forest ecosystems (Mason, 1970; Richter, 1979). To quantify the contribution of terrestrial gastropods to different ecological processes, it is necessary to estimate the biomass of snails present within an area (Hawkins at al., 1997). Weight length models provide an effective, time efficient method of determining the biomass of invertebrates (Hawkins at al., 1997). A mathematical representation of the weight length relationships (WLRs) derived from the analysis of a number of specimens of different sizes from a particular area is a useful tool for study of population dynamics. Knowledge on biological features such as weight length relationships, growth characteristics, etc. of terrestrial snails is important tool for their protection and conservation (Hawkins et al., 1997; Yıldırım et al., 2004). The WLRs have many applications in stock assessments and ecological studies. According to Stergiou and Moutopoulos (2001), the WLRs are very useful for research because they: (*i*) allow the conversion of growth in length equations to growth in weight for use in stock assessment models; (*ii*) allow the estimation of biomass from length observations; (*iii*) allow an estimate of the condition of the snails; and (*iv*) are useful for between region comparisons of life histories of certain species. Moreover, the WLRs parameters can be applied in different factors such as age, reproduction activities, amount of food and feeding, region, temperature, seasons etc. (Weatherley, 1972). In the present study, the weight and length relationships (WLRs) and meat yield of brown garden snail, *H. aspersum* and Turkish snail, *H. lucorum* were investigated in the Sinop province, Turkey.

Material and Method

Sample Collection

Two species of Helix was collected from a garden in the Sinop province in spring (April 2013) Samples were collected by hand. Collected materials were refrigerated at approximately 4°C for 4 days before being measured and weighed.

Snail shell measurement

Aperture height (AH), aperture width (AW), body-whorl height (BW); shell height (SH), shell width (SW) and height of whorls (W) were measured according to Blackket et al. (2016) (Figure 1).

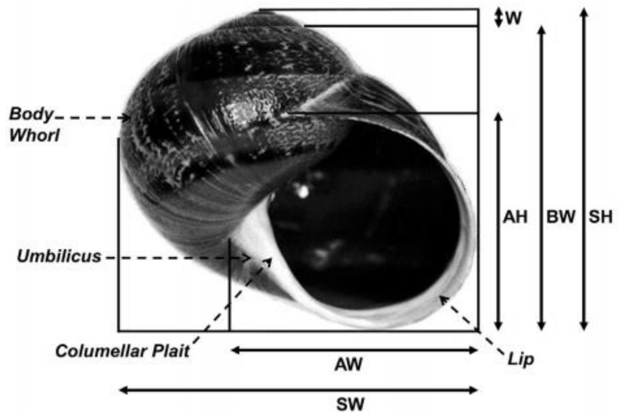

Figure 1. Snail shell with characters (From Blackket et al., 2016). Locations of shell measurements are indicated by solid arrows and lines. AH: aperture height; AW: aperture width; BW: body-whorl height; SH: shell height; SW: shell width; W: height of whorls.

Immediately after they were measured, the total live wet mass (tissue + shell) of individual gastropods was determined, to the nearest 0.001 g, on an electronic balance. Tissue separation was facilitated by breaking open the shell.

CC BY

Gastropods were then placed on a glass cover slip and the tissue was carefully removed from the shell. Then the internal organs were separated from the meat and weighed. Meat yield calculated as a percentage of the total weight of the meat without internal organ.

Weight - Length Relationships (WLRs)

The largest diameters of the shell (SW), the height (SH) of the shell and the wet body weight (BW) of two snail species (*H. lucorum* and *H. aspersa*) were measured. All specimens of the largest diameters of the shell (SW), the height (SH) of the shell were measured with a while Vernier Caliper with 0.01 mm sensitivity and weighed to the nearest 0.01 g with an electronic balance.

The WLRs, parameters were calculated and analyzed using MS Excel software. The weight length relationship was estimated as (Le Cren, 1951):

$W = aTL^b$,

where W is the body weight (g), TL refere the largest diameters of the shell (SW) and the height of the shell (SH), a is the intercept, and b is the slope of the regression line. Comparison of the difference of slope value from b = 3 (isometric growth) for all seasons, Pauly's t-test was performed (Pauly, 1984). Pauly's t-test statistic was calculated as below:

$$t = \frac{Sd_{logTL}}{Sd_{logW}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2} \quad (1)$$

where Sd_{logTL} is the standard deviation of the log TL values, Sd_{logW} is the standard deviation of the log W values, n is the number of specimens used in the computation. The value of b is different from b = 3 if calculated t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984). The comparisons the slopes of the regression lines between *H. aspersa*, and *H. lucorum* were also carried out using analysis of covariance (ANCOVA). Comparison of the difference of correlation coefficient (r) from zero t-test (Snedecor and Cochran, 1989) was calculated as follow:

$$t = \frac{r * \sqrt{(n-2)}}{\sqrt{(1-r^2)}} \quad (2)$$

where n is the number of fish used in the computation and r is the correlation coefficient. The value of correlation coefficient is different from zero if t value is greater than the tabled t values for n-2 degrees of freedom. T test to compare the means between the different sexes in PAST ver 1.75b software package (Hammer et al., 2001). Differences were considered statistically significant when P < 0.05.

Results and Discussion

A total of 153 Helix specimens (86 *H. aspersa*, 67 *H. lucorum*) were sampled in April 2018 from Sinop province. The mean shell height, shell width, body-whorl height, aperture width of *H. lucorum* was estimated statistically higher than *H. aspersa* (t test, P<0.05) (Table 1).

Table 1. Morphological variation of shell and meat yield of two helix species, *H. aspersa* and *H. lucorum*. The different superscript on the same line represents statistical differences between the two species (P < 0.05).

Snail characters	*H. aspersa*		*H. lucorum*	
	L_{mean}+*SE*	(L_{min}-L_{max})	L_{mean}+*SE*	(L_{min}-L_{max})
Shell height (mm)	31.9±0.30^a	(18.9-36.6)	35.2±0.52^b	(21.4-44.2)
Shell width (mm)	27.5±0.25^a	(16.4-31.2)	31.9±0.41^b	(19.4-38.3)
Body-whorl height (mm)	28.3±0.37^a	(24.5-31.8)	33.4±0.50^b	(27.3-40.9)
Aperture height (mm)	23.2±0.28^a	(20.7-26.8)	24.7±0.37^b	(20.9-28.7)
Aperture width (mm)	15.5±0.26^a	(13.2-15.9)	19.4±0.34^b	(14.9-23.7)
Live weight (g)	10.7±0.28^a	(2.6-16.4)	18.0±0.56^b	(5.2-29.1
Meat yield (%)	37.1±1.13^a	(33.5-51.3)	32.1±1.07^b	(19.5-41.6)

The shell height of *H. lucorum* ranged between 21.4 and 44.2 mm (mean 35.2 ± 0.52 mm) and the shell height of *H. aspersa* ranged between 18.9 and 36.6 mm (mean 31.9 ± 0.30 mm) (Table 1). The shell height frequency distributions were significantly different (Kolmogorov-Smirnov two-sample test; d = 0.562, P<0.001) between *H. lucorum* and *H. aspersa* (Figure 2). The mean shell height of *H. lucorum* was significantly (t-test, P<0.001) greater than the mean shell height of *H. aspersa*.

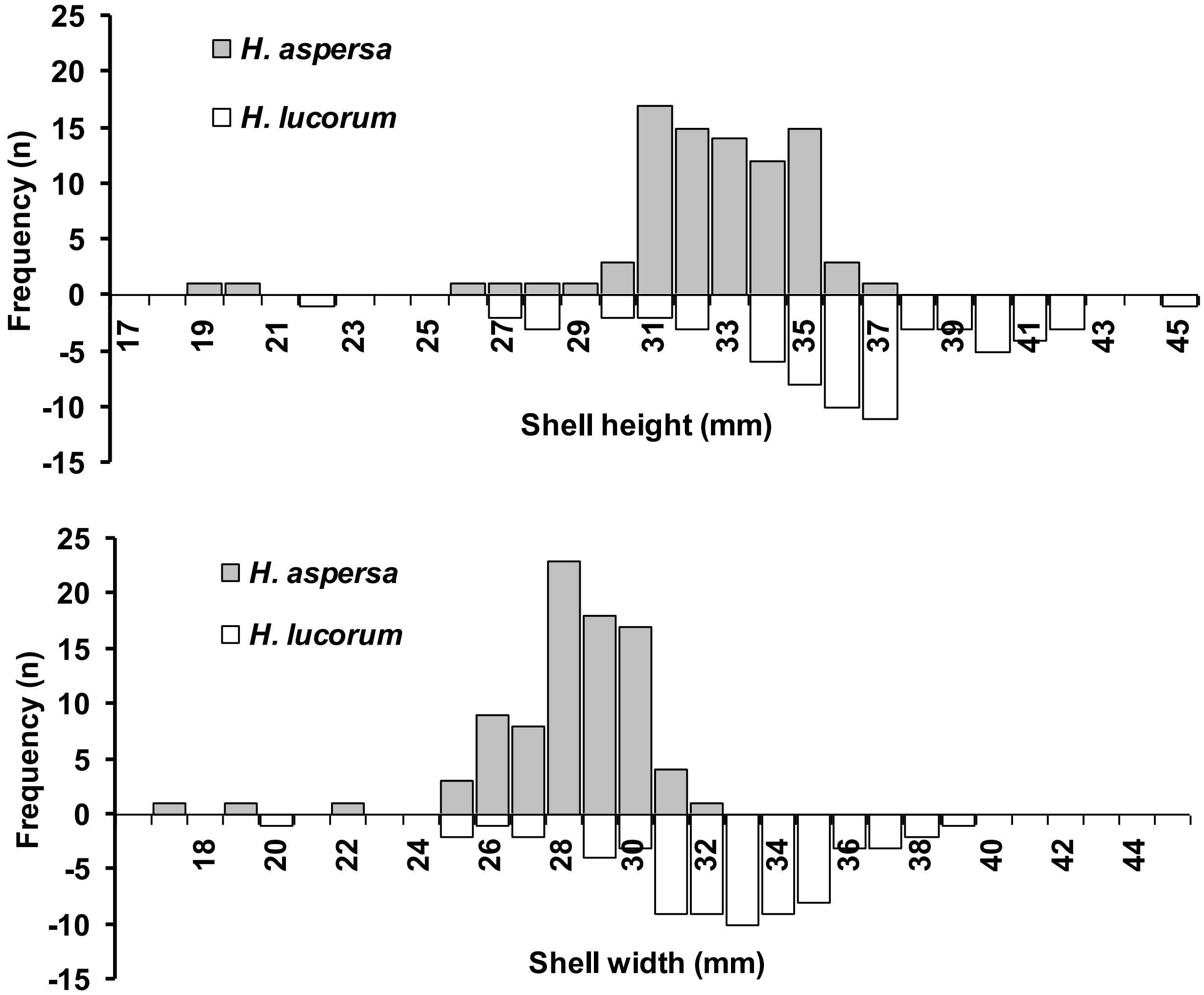

Figure 2. Shell height frequency and shell width frequency distribution of *H. aspersa* and *H. lucorum* collected from Sinop province in 2018

The shell width of *H. lucorum* ranged between 19.4 and 38.3 mm (mean 31.9 ± 0.41 mm) and the shell width of *H. aspersa* ranged between 16.4 and 31.2 mm (mean 27.5 ± 0.25 mm) (Table 1). The shell width frequency distributions were significantly different (Kolmogorov-Smirnov two-sample test; d = 0.771, P<0.001) between *H. lucorum* and *H. aspersa* (Figure 2). The mean shell width of *H. lucorum* was significantly (t-test, P<0.001) greater than the mean shell height of *H. aspersa*.

The slope of the weight- shell height relationship was significantly (ANCOVA; P<0.05) different between *H. aspersa*, and *H. lucorum*. The relationship for *H. aspersa* was: $W = 0.0097SH^{2.0163}$ ($R^2 = 0.505$; n = 86) and for *H. lucorum* it was $W = 0.0064SH^{2.2243}$ ($R^2 = 0.883$; n = 67). The slopes of the regression lines of the weight- shell height relationship for *H. aspersa* and *H. lucorum* were significantly different from the isometric growth curve slope of 3 (Pauly's t test, P<0.005) (Figure 3, 4).

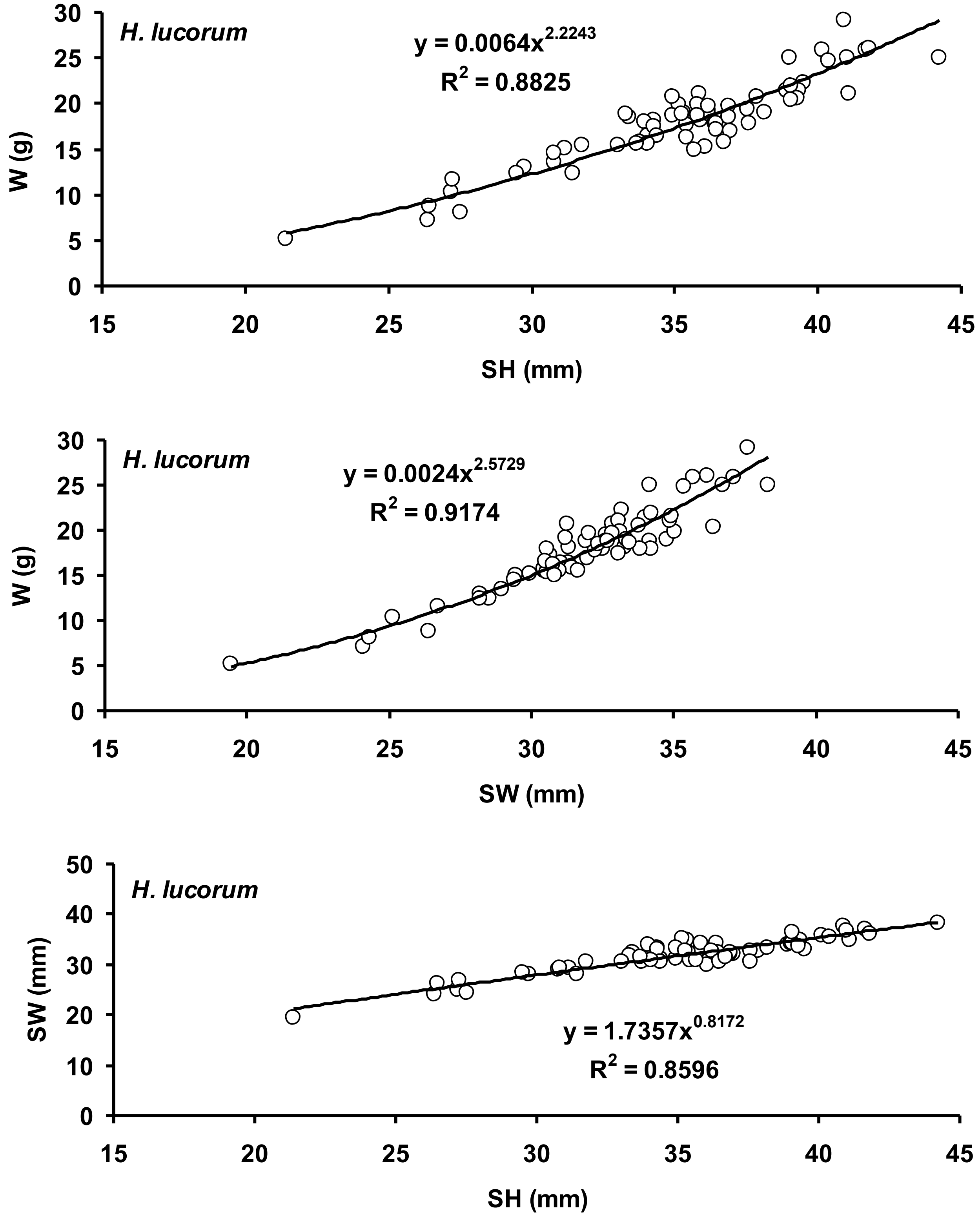

Figure 3. Shell height (SH) - weight (W), shell width (SW) - weight (W) and shell width (SW) - shell height (SH) relationships of *H. lucorum*.

CC BY

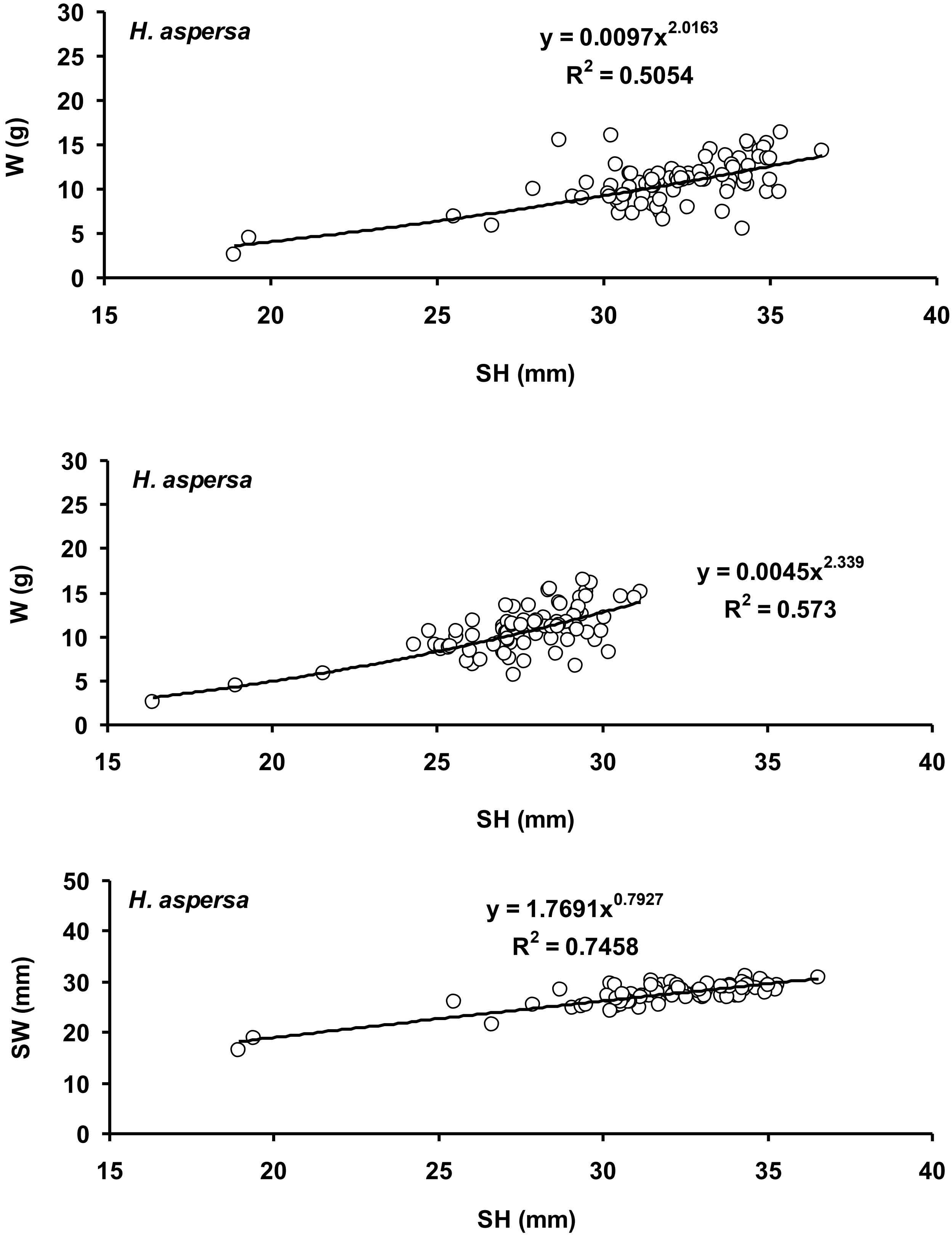

Figure 4. Shell height (SH) - weight (W), shell width (SW) - weight (W) and shell width (SW) - shell height (SH) relationships of *H. aspersa*.

The slope of the weight- shell width relationship was significantly (ANCOVA; P<0.05) different between *H. aspersa*, and *H. lucorum*. The relationship for *H. aspersa* was: $W = 0.0045SW^{2.3390}$ (R^2 = 0.573; n = 86) and for *H. lucorum* it was $W = 0.0024SW^{2.5729}$ (R^2 = 0.917; n = 67). The slopes of the regression lines of the weight- shell width relationship for *H. aspersa* and *H. lucorum* were significantly different from the isometric growth curve slope of 3 (Pauly's t test, P<0.005) (Figure 3, 4). The slope of the shell width - shell height relationship was not significantly (ANCOVA; P>0.05) different between *H. aspersa*, and *H. lucorum*. The slopes of the regression lines of the shell width - shell height relationship for *H. aspersa* and *H. lucorum* were significantly different from the isometric growth curve slope of 3 (Pauly's t test, P<0.005). The shell width - shell height relationship for *H. aspersa* was: $SW = 1.7691SH^{0.7929}$ (R^2 = 0.746; n = 86) and for *H. lucorum* it was $W = 1.7357SH^{0.8172}$ (R^2 = 0.860; n = 67) (Figure 3, 4)

The meat yield of *H. lucorum* ranged between 19.5 and 41.6 % (mean 32.1 ± 1.07 %) and the meat yield of *H. aspersa* ranged between 33.5 and 51.3 % (mean 37.1 ± 1.13 %) (Table 1). The mean meat yield of *H. lucorum* was significantly (t-test, P<0.001) lower than the mean meat yield of *H. aspersa*. The live weight of *H. lucorum* ranged between 5.2 and 29.1 g (mean 18.0 ± 0.56 g) and the live weight of *H. aspersa* ranged between 2.6 and 16.4 g (mean 10.7 ± 0.28 g) (Table 1). The mean live weight of *H. lucorum* was significantly (t-test, P<0.001) greater than the mean shell height of *H. aspersa*. Furthermore, the relationship of the met yield - shell height for *H. aspersa* was: $W = 96.944SH^{-0.2812}$ (R^2 = 0.0152; n = 30) and for *H. lucorum* it was $W = 253.8SH^{-05841}$ (R^2 = 0.0644; n = 30). The value of correlation coefficient is not different from zero (P>0.05). The relationship of the met yield - shell width for *H. aspersa* was: $W = 337.89SW^{-0.6664}$ (R^2 = 0.0436; n = 30) and for *H. lucorum* it was $W = 404.45SW^{-0732}$ (R^2 = 0.0573; n = 30). The value of correlation coefficient is not different from zero (P>0.05) (Figure 5, 6).

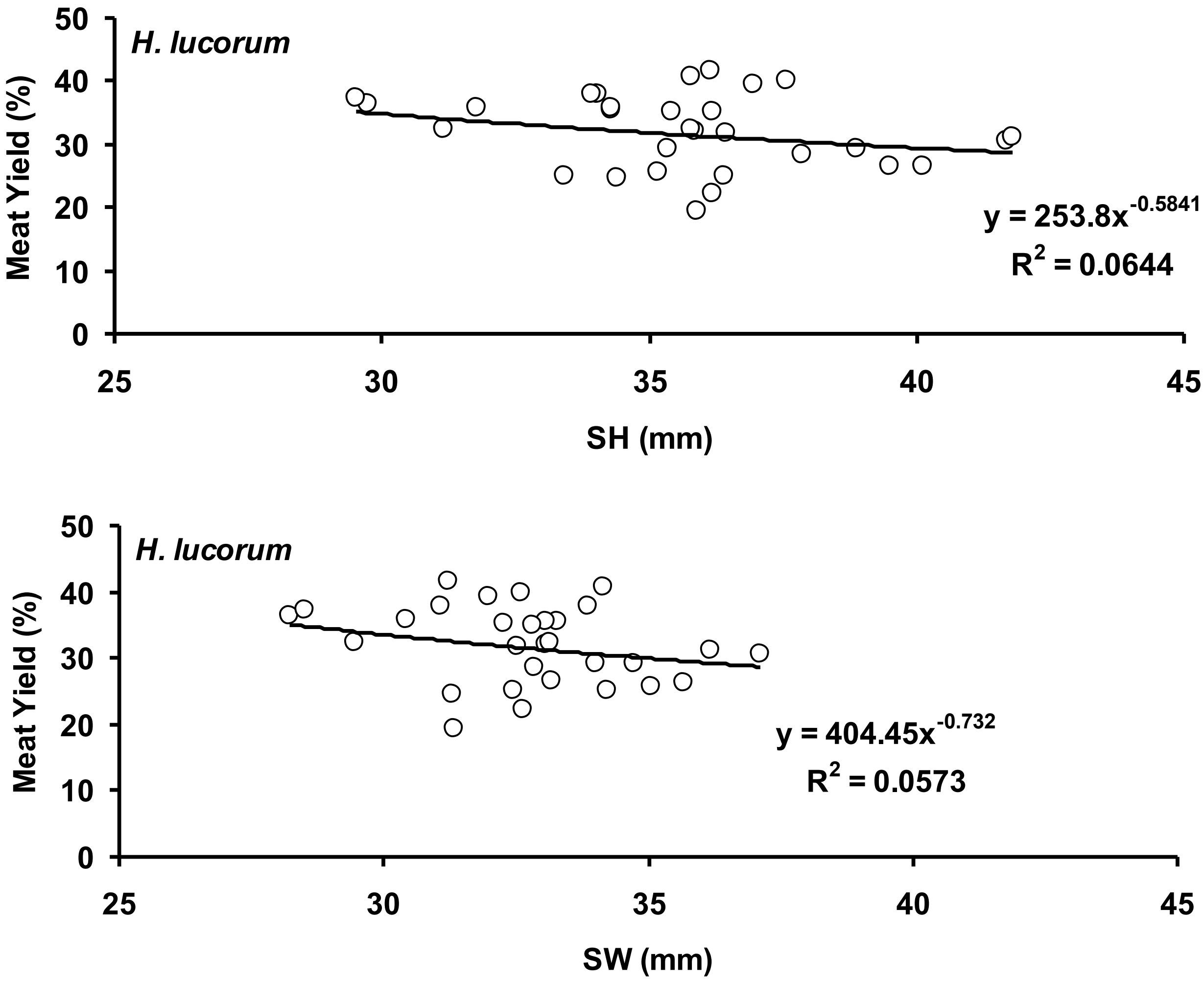

Figure 5. Meat yield - shell width (SW) and Meat yield - shell height (SH) relationships of *H. lucorum*

CC BY

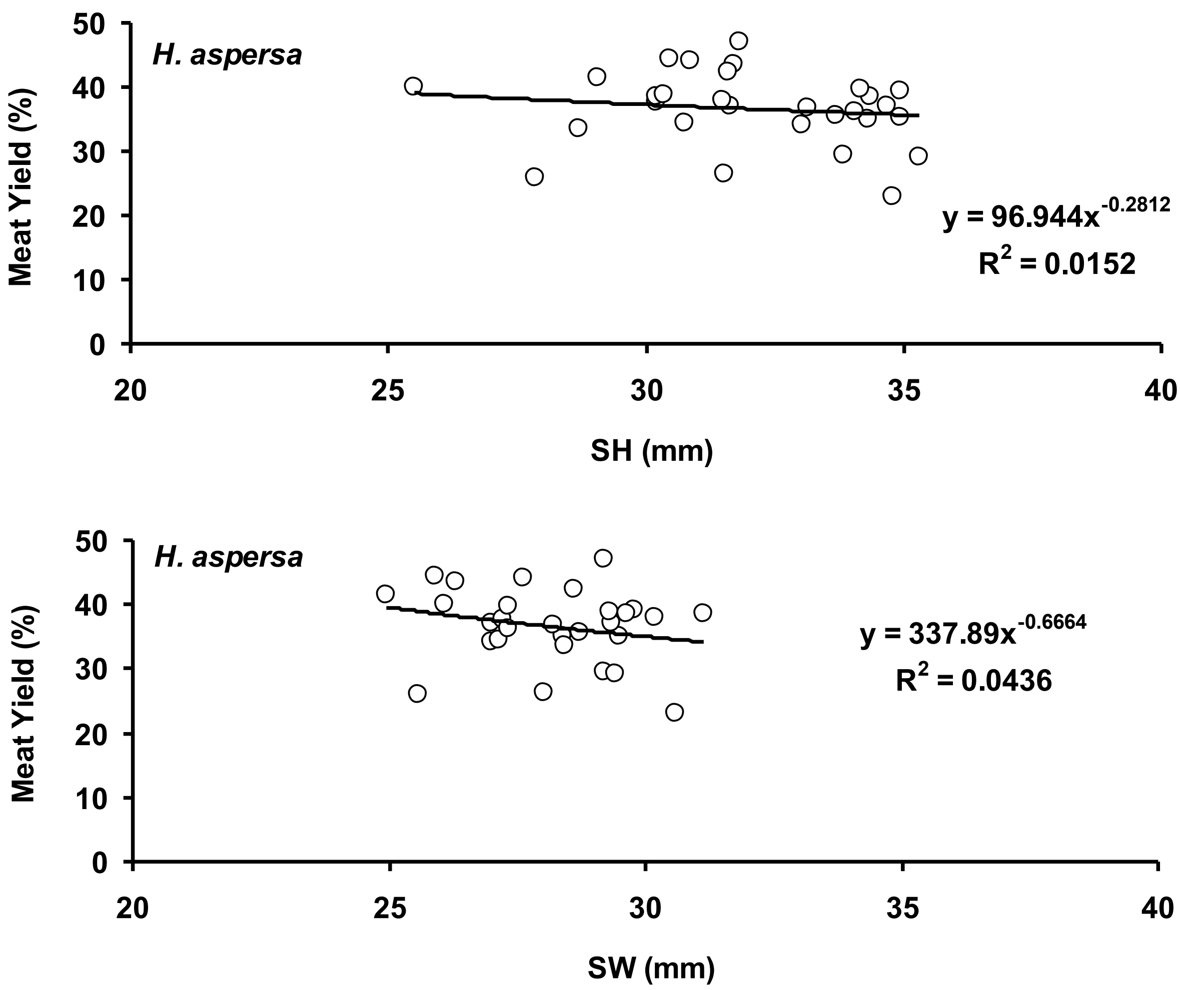

Figure 6. Meat yield - shell width (SW) and Meat yield - shell height (SH) relationships of *H. aspersa*

Morphological variation of shell for two helix species, H. aspersa and H. lucorum were not study detail in the previous studies. There are only two studies (Yıldırım et al., 1999; Duman, 2015) reported shell height, live weight and meat yield of these terrestrial snails' species (Table 2).

Table 2. Shell height, live weight and meat yield of two helix species, *H. aspersa* and *H. lucorum* reported from different studies

Season	Shell height (cm)	Live weight (g)	Meat yield (%)	Species	References
Spring	4.1±0.02	18.5±0.22	22.6±0.29	*H. lucorum*	Duman, (2015)*
Winter	4.0±0.03	17.1±0.61	23.7±0.90	*H. lucorum*	Duman, (2015)*
Autumn	3.9±0.19	18.2±2.43	22.4±1.99	*H. lucorum*	Duman, (2015)*
Summer	3.9±0.09	18.4±1.36	22.7±0.44	*H. lucorum*	Duman, (2015)*
All data	4.0±0.05	18.1±0.63	22.9±0.50	*H. lucorum*	Duman, (2015)*
All data	3.2±0.32	16.1±3.33	33.7±1.48	*H. lucorum*	Yıldırım et al. (1999)**
Spring	3.5±0.02	10.8±0.34	24.9±0.90	*H. aspersa*	Duman, (2015)*
Winter	3.5±0.03	10.0±0.43	23.5±0.77	*H. aspersa*	Duman, (2015)*
Autumn	3.3±0.06	8.8±0.85	23.2±2.09	*H. aspersa*	Duman, (2015)*
Summer	3.4±0.02	10.6±0.27	20.8±0.64	*H. aspersa*	Duman, (2015)*
All data	3.4±0.03	10.0±0.33	23.1±0.69	*H. aspersa*	Duman, (2015)*

*: The seasonal averages are calculated from the monthly averages by us, data obtained between June 2012 and May 2013 from Sinop Province in the Middle Black Sea region climate. **: The averages are calculated by us, the data obtained between February and July from Isparta Province in the Mediterranean region climate.

CC BY

Our results showed that *H. lucorum* was higher shell features such as SH, SW and live weight than *H. aspersa*. The mean shell height of *H. lucorum* was reported as 4.0±0.05 cm by Duman (2015) and as 3.2±0.32 cm by Yıldırım et al. (1999). The mean shell height was also reported for *H. aspersa* as 3.4±0.03 cm by Duman (2015). The mean live weight of *H. lucorum* was reported higher than *H. aspersa* (Table 2). Similar result was obtained by the present study. Minor seasonal differences of shell height, live weight and meat yield were reported for two species from Sinop province by Duman (2015). This result suggests that *H. lucorum* and *H. aspersa* can not show non-seasonal variation in growth. Meat yield of *H. lucorum* reported as 22.9±0.50% and 23.1±0.69 % for *H. aspersa*. But we calculated meat yield higher than previous study which is conducted same area with our study. This difference may be explained by differences of biotic and a biotic factor such as age, reproduction activities, amount of food and feeding, region, temperature etc. (Weatherley, 1972) which can effect the snails' growth among the years.

The weight – shell height, weight – shell width and shell height - shell width results suggested that two helix species showed negative allometric growth characteristics ($b<3$, $P<0.05$). The b is the coefficient balancing the dimensions of the equation and its values can be smaller, larger or equal to 3 (Lleonart et al., 2000). In the first two cases (i.e., $b<3$ and $b>3$) snails growth is allometric (i.e., when $b<3$ the snail grows faster in weight than in length), whereas when $b=3$ growth is isometric.

Conclusion

In the previously studies, biochemical composition of meat, meat yield and reproduction of edible terrestrial snails of Turkey were studied (Yıldırım et al., 1999; Yıldırım et al., 2004; Duman, 2015). Furthermore, the presence of the Turkish snail (*H. lucorum*) in the Slovak Republic (Čejka and Čačaný, 2014) and in Le Vesinet, a western suburb of Paris (Mienis and Rittner, 2010) was reported. In the present study, the weight and length relationships and meat yield of brown garden snail, *H. aspersum* and Turkish snail, *H. lucorum* were investigated in the Sinop province, Turkey. We did not compare our result with other studies because of the fact that there is no information about the weight length relationships of the two species. The present study can be use for future researches for cooperation to their results.

References

Blacket, M.J., Shea, M., Semeraro, L. and Malipatil, M.B., 2016. Introduced Helicidae garden snails in Australia: morphological and molecular diagnostics, species distributions and systematics. Records of the Australian Museum 68: 99–116.

Burch, J.B., 1960. Some snails and slugs of quarantine significance to the United States. U.S. Department of Agriculture Research Service 82: 1-70.

Capinera, J.L., 2001. Handbook of vegetable Pests. Academic Press., USA, San Diego.

Čejka, T. and Čačaný, J., 2014. The first record of the Turkish snail (*Helix lucorum* L., 1758) in the Slovak Republic. Malacologica Bohemoslovaca 13: 124–125.

Digweed, S.C., 1993. Selection of terrestrial gastropod prey by cychrine and pterostichine ground beetles (Coleoptera: Carabidae). The Canadian Entomologist 125: 463 - 472.

Duman, M.B., 2015. Determination of biochemical composition, meat yield and reproduction of land snails, Helix aspersa and Helix lucorum, in Sinop. Msc Thesis, Sinop University (Unpublished), Turkey.

Hammer Ø., Harper D. A. T. and Ryan P. D., 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4: 1- 9.

Hawkins, J.W., Lankester, M.W., Lautenschlager, R.A. and Bell, F.W., 1997. Length - biomass and energy relationships of terrestrial gastropods in northern forest ecosystems. Canadian Journal of Zoology 75: 501-505.

Le Cren, C.D., 1951. Length-weight relationship and seasonal cycle in gonad weight and condition in perch (*Perca fluviatilis*). Journal of Animal Ecology 20: 201-219.

Lleonart, J., Salat, J., Torres and G.J., 2000. Removing allometric effects of body size in morphological analysis. Journal of Theoretical Biology 205: 85 – 93.

Mason, C.F., 1970. Snail populations, beech litter production and the role of snails in litter decomposition. Oecologia 5: 215 - 239.

Mienis, H.K. and Rittner, O., 2010. On the presence of *Helix lucorum* Linnaeus, 1758 (Mollusca, Gastropoda, Helicidae) in Le Vesinet, a western suburb of Paris. Journal électronique de la malacologie continentale française 6: 266-267.

Mumladze, ., Tarkhnishvili, D. and Pokryszko, B.M., 2008. A new species of the genus Helix from the lesser Caucasus (SW Georgia). Journal of Conchology 39: 483-486.

Nordsieck, R., 2018. The Turkish snail (*Helix lucorum* L.). In: the living world of mollusks. <www.molluscs.at> downloaded on 12 April 2018.

Pauly, D., 1984. Fish population dynamics in tropical water: a manual for use with programmable calculators. The International Center for Living Aquatic Resources Management, Makati, Metro Manila, Philippines.

Reinink, K., 2005. *Helix lucorum* Linnaeus, 1758 nu ook in Nederland. Spirula 342: 2-3.

Richter, K.O., 1979. Aspects of nutrient cycling by *Ariolimax columbianus* (Mollusca: Arionidae) in Pacific Northwest coniferous forests. Pedobiologia 19: 60 - 74.

Snedecor, G.W. and Cochran, W.G., 1989. Statistical methods, Iowa State University Press., Ames, Iowa.

Stergiou, K.I. and Moutopoulos, D.K., 2001. A review of length-weight relationships of fishes from Greek marine waters. Naga, the ICLARM Quarterly 24: 23-39.

Weatherley, A.H., 1972. Growth and ecology of fish populations., Academic Press. London.

Yıldırım, M.Z., Özen, M. R., Ünlüsayın, M. and Gülyavuz, H., 1999. A study on the flesh productivity and standard method for collecting of Helix lucorum Linnaeus, 1758. Turkish Journal of Zoology 23: 747-750.

Yıldırım, M.Z., Kebapçi, Ü. and Gümüş, B.A., 2004. Edible snails (terrestrial) of Turkey. Turkish Journal of Zoology 28: 329-335.