Studies on the Edible Terrestrial Snails Helix aspersa Muller Food Conversion Ratio in a Confined Microclimate System

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Abstract
Terrestrial edible snail breeding is an agricultural activity that finds itself at pioneering stage in Romania. One of the species used in snail farming is *Helix aspersa* Muller. In order to accelerate their growth, farmers feed the snails with pumpkins as well as concentrated forage consisting of mix of flours to which calcium carbonate is added in order to supplement snails need for shell's development. In a controlled microclimate environment we measured the average growth of six weeks old *Helix aspersa* Muller snails placed in four different plastic enclosures. The consumption of different type of foods within 24 hours period was measured. The wheat (60%), corn flour (20%) and calcium carbonate (20%) mix had a superior food conversion ratio (FCR) of 4.80, whereas the second FCR registered 6.04 in the case of 53% pumpkin and 47% flour mix served in the same time followed by the pure fresh vegetable mix accounting for a FCR of 8.00 and by 19.02 when only the pumpkin has been administrated as meal. During the experiments the snails did not have access to soil, being known that soil is an integral part of their diet.

Keywords: Cornu aspersum, ecological snail farm management, FCR, helicicultura, mollusk, weight gain.

1. Introduction

Yarimburgaz Cave, Turkey, offers evidences of the use of terrestrial snails *Helix pomatia* for consumption since prehistoric times, relates Meric in his works [1]. Dalby [2] during his archeological research dates snail shell sediments found in Franchthi Cave, Greece, to 10,700 BC. Breeding terrestrial edible snails in Romania, *Helix pomatia* and *Helix aspersa* Muller species, is an agricultural activity that finds itself at pioneering stages. Such activity needs to be encouraged given the ecological character it has [3] and discouraging the collection of snails from nature not only due to the European Union legislation but due to the heath hazards presents the snails collect from contaminated areas with pesticides and heavy metals [3,4]. In order to accelerate their growth, farmers feed the snails with different crops including pumpkins as well as concentrated forage such as flour mixes to which calcium carbonate is being added in order to supplement snail's calcium need for shell's development.

2. Materials and methods

The studies took place between September 1-st and September 8-th, 2009, and were repeated 5 times, 24 hours of continuous feeding time per each session with a few hours of maintenance, cleaning and measurements break time between repetitions.

2.1. Study area – The experiments were conducted inside a laboratory room using 4 boxes, plastic enclosures, each L 25cm x W 20cm x H 15cm, all provided with a lid on top. We added food grade

plastic trays inside for holding the feed and the drinking water for snails such way as to have it at their discretion. The enclosures were provided with small vents to allow proper air circulation. During experiments the snails did not have access to soil, being known that snails do consume soil [5, 6.].

2.2. Microclimate - The air temperature and humidity indicated in Table 1. were recorded using a USB-502 data logger supporting a range of -35^{o}C to +80^{o}C (±1^{o}C) and 0% to 100% relative humidity, placed in the control box V1-C, assuming that the temperature in the boxes would be similar given the fact that they were kept all 4 in the same room. The temperature kept basically close to the laboratory's room temperature starting at 21^{o}C increasing to a 23^{o}C at the end of the 24 hours experiment. The humidity was the lowest at the beginning of the experiment and increased gradually after closing the lid on the enclosures reaching a maximum of 92% just at the end of the 24 hours experiment.

Table 1.-Microclimat conditions during the experiments

	Temperature	Humidity
maximum	23^{o}C	92 %
minimum	21^{o}C	60 %
average	22^{o}C	80 %

2.3. Snail species –We used in our study as much as possible a homogenous population of *Helix aspersa* Muller 6 weeks old (Figure 1.) raised in a snail farm located in Vaslui County, Romania. In each enclosure we introduced 100 snails and fed them differently.

Figure 1. – *Helix aspersa* Muller six weeks old feeding on pumpkin and flour mix (V4-E box)

The same operation has been repeated 5 times, every day with a few hours between feeding sessions such way to allow for measurements, cleaning of the enclosures, feeding.
During the maintenance and measurements sessions the snails were not fed; therefore we did not expect them to gain an overall weigh during this entire study period of time.
Our interest was to observe and quantify the food conversion ratio (FCR) considering that the data will be affected by the stress factors the snails were exposed to during this feeding regiment in confined enclosures and even more, they were deprived of soil from where they can feed themselves [5, 6.].

2.4. Feed used – Snails are very aggressive herbivores [7]. Freshly cut greens as listed in Table 2. were given as feed to snails in the control enclosure V1- C. The pumpkin was also freshly cut

Table 2.-feed composition used for the experiment

Boxes	Feed
V1 – C Control (Mixed green feed)	Taraxacum officinales Sonchus oleraceus, Equisetum arvense, Lupinus polyphyllus Lactuca sativa
V2 – E (Pumpkin)	Curcubita maxima
V3 – E (Flour Mix)	wheat flour 60% corn flour 20% CaCo3 20%

V4 – E (Pumpkin and Flour Mix)	Pumpkin 53% Flour Mix 47%

and administered alone in V2-E enclosure and also in combination with flour mix in V4-E (Figure 1.). In the V3-E enclosure the snails were given just flour mix (Figure 2.).

All of the enclosures were provided with drinking water using food grade plastic dishes such as to provide snail's free access to water but not to provoke accidental access. The water level was low enough as to prevent snail's drawing, snails being extremely small.

2.5. Measurements - At the beginning of the study, the weight of the *Helix aspersa* Muller six weeks old snails population was taken. Grups of 100 snails were measured using an AWS weight scale with a precision of ±0.01 gram for each of the enclosures. At the end of every 24 hours feeding period, the weight measurements of the entire population from each box was taken and recorded. The procedure took place repeatedly 5 times, therefore accounting for 5 repetitions for every box, 5 consecutive days.

2.7. Statistics - For data statistical interpretation we used GraphPad 5.03 and Excel module from Microsoft Office 2003. Column statistics and ANOVA test incorporating the Dunnett's Multiple Comparison Test has been performed for all data.

Table 3. – Consumption and weight gain within 24 hours by *Helix aspersa* Muller 6 weeks old raised in enclosed microclimate, fed with mixed greens (grams)

		V 1 – (C) *Mixed green feed*			Snail's weight (SW) and Snai's Weight Gain (SWg)		
		Introduced	Remains	Consumed	SW_i *(initial)*	SW_f *(final)*	SWg *(gain)*
Repetitions	R 1	69.13	51.25	17.88	119.61	121.89	2.28
	R 2	68.37	50.05	18.32	122.04	124.35	2.31
	R 3	60.20	42.01	18.19	118.22	120.48	2.26
	R 4	62.48	44.14	18.34	118.77	120.98	2.21
	R 5	56.29	38.17	18.12	121.02	123.31	2.29
$\bar{x} = \frac{\sum x}{n}$		63.29 ±2.44	45.12 ±2.46	18.17 ±0.08	119.90 ±0.71	122.20 ±0.72	2.27 ±0.02

Table 4. – Consumption and weight gain within 24 hours by *Helix aspersa* Muller 6 weeks old raised in enclosed microclimate, fed with pumpkin (grams)

		V 2 – (E) *Pumpkin*			Snail's weight (SW) and Snai's Weight Gain (SWg)		
		Introduced	Remains	Consumed	SW_i *(initial)(g)*	SW_f *(final)(g)*	SWg *(gain)(g)*
Repetitions	R 1	52.14	23.45	28.69	122.11	123.55	1.44
	R 2	52.03	23.41	28.62	120.07	121.61	1.54
	R 3	63.94	34.22	29.72	119.86	121.50	1.64
	R 4	62.75	32.44	30.31	120.02	121.65	1.63
	R 5	73.23	42.22	31.01	121.08	122.61	1.53
$\bar{x} = \frac{\sum x}{n}$		60.82 ±4.00	31.15 ±3.56	29.67 ±0.46	120.60 ±0.43	122.20 ±0.40	1.56 ±0.04

3. Results and discussion

During the experiment, snail's behavior has been observed. Their appetite for specific foods such as presented in Figure 1. where snails are fed with pumpkin and flour mix, combination assuring a better intestinal transit. Feeding snails with just dry feedstuff such as mix flower (Figure 2.) the presence of water supply is a must [8]. The mean of mixed green feed intake (Table 3) was 18.17±0.08 grams inducing a snail weight gain of

Figure 2. – *Helix aspersa* feeding on flour mix (V3-E box)

Table 5. – Consumption and weight gain within 24 hours by *Helix aspersa* Muller 6 weeks old raised in enclosed microclimate, fed with pumpkin (grams)

		V 3 – (E) *Mixed flour*			Snail's weight (SW) and Snai's Weight Gain (SWg)		
		Introduced	Remains	Consumed	SW_i *(initial)*	SW_f *(final)*	SWg *(gain)*
Repetitions	R 1	56.19	10.07	46.12	122.77	132.65	9.88
	R 2	60.10	12.98	47.12	125.06	135.08	10.02
	R 3	60.78	12.77	48.01	129.65	139.77	10.12
	R 4	58.35	11.33	47.02	128.32	137.75	9.43
	R 5	59.60	12.57	47.03	127.03	136.65	9.62
$\overline{x} = \frac{\sum x}{n}$		59.00 ±0.81	11.94 ±0.55	47.06 ±0.30	126.60 ±1.21	136.40 ±1.21	9.81 ±0.13

Table 6. – Consumption and weight gain within 24 hours by *Helix aspersa* Muller 6 weeks old raised in enclosed microclimate, fed with pumpkin and four mix (grams)

		V 4 – (E)						Snail's weight (SW) and Snai's Weight Gain (SWg)		
		Pumpkin			*Mixed flour*			SW_i	SW_f	SWg
		Intro-duced	Re-mains	Con-sumed	Intro-duced	Re-mains	Con-sumed	*(initial)*	*(final)*	*(gain)*
Repetitions	R 1	21.80	5.36	16.45	19.34	4.75	14.58	121.79	126.33	4.54
	R 2	22.78	6.83	15.96	20.21	6.05	14.15	120.08	125.26	5.18
	R 3	23.14	7.29	15.85	20.52	6.46	14.06	122.53	128.22	5.69
	R 4	22.41	6.55	15.86	19.88	5.81	14.07	125.31	130.30	4.99
	R 5	22.04	6.43	15.60	19.54	5.71	13.84	127.03	131.51	4.48
$\overline{x} = \frac{\sum x}{n}$		22.43 ±0.24	6.49 ±0.32	15.94 ±0.14	19.90 ±0.22	5.76 ±0.28	14.14 ±0.12	123.30 ±1.25	128.30 ±1.17	4.98 ±0.22
Levels of feed consumed in tandem				53 %			47 %			
Total feed consumed in tandem					30.08 g ±0.13					

Table 7. Statistical Analysis - ANOVA TEST
on the *Helix aspersa* Muller 6 weeks old snail mean consumption rate during a 24 hours experiment

Dunnett's Multiple Comparison Test	Mean Diff,	q	Significant? P < 0,05?	Summary	95% CI of diff
V 1 (C) vs. V 2 (E)	-11.50	24.46	Yes	***	-12.76 to -10.24
V 1 (C) vs. V3 (E)	-28.89	61.44	Yes	***	-30.15 to -27.63
V 1 (C) vs. V4 (E)	-11.91	25.34	Yes	***	-13.18 to -10.65

Table 8. Statistical Analysis - ANOVA TEST
on the *Helix aspersa* Muller 6 weeks old snail mean weight gain during a 24 hours experiment

Dunnett's Multiple Comparison Test	Mean Diff,	q	Significant? P < 0,05?	Summary	95% CI of diff
V 1 (C) vs. V 2 (E)	0.7140	4.399	Yes	**	0.2786 to 1.149
V 1 (C) vs. V3 (E)	-7.544	46.48	Yes	***	-7.979 to -7.109
V 1 (C) vs. V4 (E)	-2.706	16.67	Yes	***	-3.141 to -2.271

Table 9. – Food Conversion Ratio within 24 hours by *Helix aspersa* Muller 6 weeks old raised in enclosed microclimate

Specificare	V 1 – (C) Mixed green vegetables	V 2 – (E) Pumpkin	V 3 – (E) Flour mix	V 4 – (E) Pumpkin 53% Flour mix 47%
Average Food Intake (g)	18.17	29.67	47.06	30.08
Initial Average Weight (g)	119.93	120.63	126.57	123.35
Food Intake vs. Initial body weight	15.15 %	24.60 %	37.19 %	24.40 %
Weight gain (g)	2.27	1.56	9.81	4.98
Food Conversion Rate (FCR)	8.00	19.02	4.80	6.04

2.27±0.02 grams. Avagnina [8] implies a 10 to 1 FCR in his works. The food intake in the case of pumpkin alone, as presented in Table 4., registered a mean of 29.67±0.46 grams offering a barely 1.56±0.04 grams weight gain. During the study we observed the excrements as well (Figure 3.), collected with the intention to investigate their biochemical content. Unfortunately, the budget did not allow us to conduct further research, limiting ourselves to subjective observations. The color of excrements composition reflects in good part the type of foodstuffs intake and their relative proportion. Therefore, certain type of foods can play the roll of food markers that can be used for further investigations in regards to snails nutrition and perhaps to other animals as well.

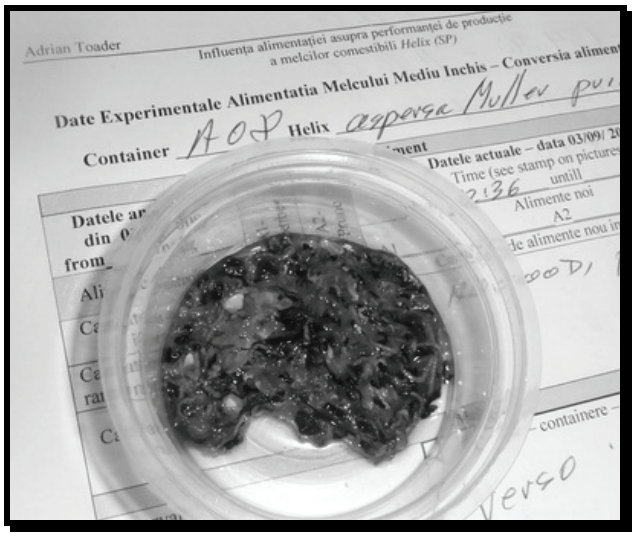


Figure 3. The colors of the *Helix aspersa* snail excrements are good markers to asses their food intake

Table 10. - Weight values response on *Helix aspersa* Muller 6 weeks old raised during 24 hours experiment

	Enclosure, Box	n	X ± s_x		Relative results (%)	V%
Average Food Intake (g)	V 1 (C)	5	18.17±0.08		100.00	1.02
	V 2 (E)	5	29.67±0.46	***	163.29	3.48
	V3 (E)	5	47.06±0.30	***	259.00	1.42
	V4 (E)	5	30.08±0.13	***	165.55	1.94
Weight gain (g)	V 1 (C)	5	2.27±0.02		100.00	1.68
	V 2 (E)	5	1.56±0.04	00	68.72	5.27
	V3 (E)	5	9.81±0.13	***	432.16	2.91
	V4 (E)	5	4.98±0.22	***	219.38	9.99
Food Conversion Ratio (FCR)	V 1 (C)	5	8.00		100.00	na
	V 2 (E)	5	19.02		238.41	na
	V3 (E)	5	4.80		59.98	na
	V4 (E)	5	6.04		75.51	na

***- p<0,001- very significant positive differences, 00 - p<0,01 – distinct significant negative differences.

As further on we present in Table 5., the dry foodstuff consisting of mixed flour (box V3-E) registered a mean of 47.06±0.30 grams conducting to a weight gain with a mean of 9.81±0.13 grams. The combination of pumpkin 53% with 47% mixed flour, Table 6., it was consumed very well accounting together to a mean of 30.08±0.13 grams total intake, resulting into a snail's weight gain of 4.98±0.22 grams.

Conducting ANOVA test and Dunnett's multiple comparison test, the results show on snail mean consumption rate during the 24 hours feeding experiments, presented in Table 7., values such as:

V 1 (C) vs. V 2 (E) very significant positive differences.

V 1 (C) vs. V3 (E) very significant positive differences.

V 1 (C) vs. V4 (E) very significant positive differences.

The results show on snail mean weight gain rate during the 24 hours feeding experiments, presented in Table 8., values such as:

V 1 (C) vs. V 2 (E) significant positive differences.

V 1 (C) vs. V3 (E) very significant positive differences.

V 1 (C) vs. V4 (E) very significant positive differences.

Examination of the values presented in Table 9. is suggesting the fact that the values of are very much in the range presented by Bura [9] that mentions an average food intake of 0.5 grams for the 30-90 days old snails (in this experiment the snails are like 40-50 days old), in regards to the quantity of food intake by different sizes/weight/age of the snails, the range being closer in the case of flour mix feeding (V3-E). The results in the rest of feeding regiments were lower, based on the suggestive numbers, but the values are not too far. Also, Murphy in his RIRDC Report [10], indicates that the food intake by snails can reach up tu 40% of their body weight, comparable with our data (Table 9.) ranging from the lowest of 15.15% in the case of mixed green vegetables as the only foodstuff (V1-C control box) to as high as 37.19% found in the case of the flour mix as the only feed (V1-E box)

Conducting ANOVA test and Dunnett's multiple comparison tests on weight values responses and FCR as well, as presented in Table 10., considering the control situation, that is supposing to mimic the natural snail's feeding with fresh green vegetables only, as being the 100% relative intake, 100% relative weight gain and respectively 100% for FCR we obtained:

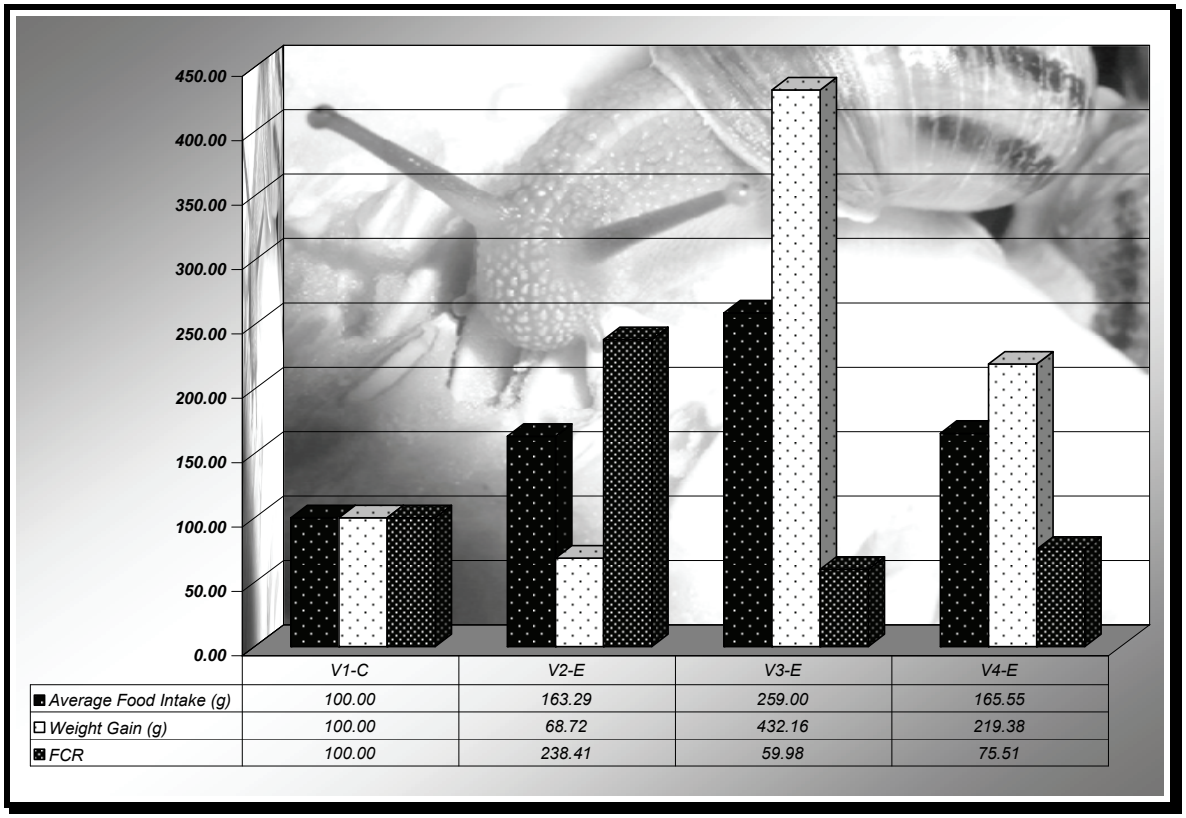
For the weight values responses on average food intake a 163.29% for V2-E, very significant positive differences, for V3-E as much as 259.00%,

very significant positive differences, for V4-E 165.55%, very significant positive differences.

The weight values responses on weight gain are low 68.72% for V2-E, significant negative differences, and the highest of all the 432.16 % for V3-E, very significant positive differences.

The V4-E presents 219.38%, conducting to very significant positive differences as well.

The values are also representative as we make them more visual with the help of the graphic represented in Figure 4.



	V1-C	V2-E	V3-E	V4-E
Average Food Intake (g)	100.00	163.29	259.00	165.55
Weight Gain (g)	100.00	68.72	432.16	219.38
FCR	100.00	238.41	59.98	75.51

Figure 4. – ANOVA test and Dunnett's multiple comparison tests on weight values responses and FCR

4. Conclusions

The results obtained gives us an idea about their food intake and weight gain ratio, but we must consider the soil deprivation from their nutrition as a stress factor, as well as the stress induced to them due to their confinment and due to their exposure to weight measurements activities and so on, way far from their natural or even farming living conditions.

The best Food Conversion ratio (FCR) has been obtained in the case of feeding them with flour mix (V3-E), situation when they had plenty of water at their discretion, but the cost of such foodstuff must be highly considered when taken in account for the snail farming efficiency evaluation, for farming economics and for the ecological impact such agricultural activity can have . The same is the case with the FCR = 6.04, obtained in the case presented by V4-E. Here, the cost of the foodstuff production

may be high enough to consider the control situation as being the optimum. Further economic studies would be welcomed, perhaps will put a light on the best economic and ecological snail breeding, growing, farming technologies.

Certain type of foods can play the roll of food markers that can be used for further investigations in regards to snail's nutrition and perhaps in can be applied in the research of nutrition and related domains of other animals as well.

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