Chapter

Indoor Hibernation of *Helix aspersa* Juveniles

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Abstract

The "Italian" outdoor snailfarming technology assumes that both mature and juvenile snails hibernate outdoor, protected by a thin sheet of unweaved coverlet (agryl sheet). In contrast, the "French" snailfarming technology implies that only mature brown garden snails (*Helix aspersa*) hibernate indoor, in strictly controlled microenvironmental parameters (temperature, humidity, and ventilation). This technology may also be viable for *H. aspersa* juveniles. Extremely high death rates occurring in Romanian outdoor snailfarms during colder winters (>80%) imposed the need to find alternative paths for a proper hibernation of *H. aspersa*. Using statistical analyses, close surveillance of technological flow, and controlled microenvironmental parameters, we assessed the possibility to adapt indoor hibernation for *H. aspersa* juveniles. The experiments lasted for 2 years (2006–2008) and were carried out on 34,000 *H. aspersa* juveniles and 15,000 mature ones, using different technological flows and microenvironmental parameters (temperature, humidity, and ventilation). They were performed in two stages and involved five case studies, conducted independently in three different locations: Floreşti (Mehedinţi county), Sântuhalm (Hunedoara county), and Muntenii de Sus (Vaslui county). The first stage tested the hypothesis in relation to survival rate of mature snails, *H. aspersa*, in the same conditions, whereas the second stage improved the technological flow, before its extensive application. We demonstrated that noncontrolled microclimate parameters (temperature, humidity, and ventilation) and the use of straw as hibernation support induced significant differences ($P < 0.01$) concerning death levels of *H. aspersa* juveniles as compared to their indoor hibernation in semicontrolled microclimate (temperature and ventilation). In the same hibernation microclimate, mature snails exhibited higher survival levels than the juvenile ones, irrespective of technological flow and origin ($P < 0.0001$). We also demonstrated that juveniles' weight loss displays a relatively constant variation (16.33–20.51%). In addition, the correlations between the individual average weight before and after hibernation were described by the same logarithmic regression. Furthermore, significantly higher survival rates of *H. aspersa* juveniles ($P < 0.0001$) have been registered when they had not been awakened during hibernation. Finally, we proved that indoor hibernation of *H. aspersa* juveniles in strictly controlled microenvironmental parameters (temperature, humidity, and ventilation) could represent a viable technology that improves the technological flow in outdoor snailfarming during wintertime in colder climates.

Keywords: microenvironment, snailfarming, hibernation, technology, monitored

1. Introduction

In a continental climate, characterized by higher rainfall levels than on countries with tradition in snailfarming (France, Italy, Spain, Greece), in Romania this activity registered a booming development during the 2003–2007 time period [1]. Thus, in 2006, according to the International Institute of Snail Farming from Cherasco (Italy), Romania ranked second in the world concerning the number of outdoor snailfarms (>1000) and their sown area. The "French" snailfarming technology implies that the snails are bred in captivity, and juveniles are introduced early in the spring in outside fattening pens, wherein they are fed primarily a combination of concentrated fodders [2]. As a result, most snails reach adulthood from 6 to 8 months, and in autumn they are sold as final product. Only a small proportion of adult gastropods is kept as reproductive herd for the next year productive cycle and hibernate in strictly controlled indoor environment [3]. The immature juveniles are not gathered; therefore, they are let to survive outside during wintertime, without any additional protection [4]. In contrast, the "Italian" snailfarming technology snails employs the biological cycle of raising and growing snails in open pastures of fresh vegetables [5]. A typical farm is organized in pens with precise destinations: 60% for breeding and 40% for fattening [6]. The fattening pens are used starting from the second year of activity onward, when after hibernation, snails are transferred from the breeding pens into the fattening pens [7]. When winter arrives, snail of many sizes, starting from hatchlings to adult ones, are found inside the pens [1]. The solution used for snail hibernation relies on trimming the vegetation inside the pens to 20 cm in height, whereas the pens are covered with unweaved coverlet (weight = 18–25 grams per square meters, i.e., g/m^2)—material also known as agryl sheet [8, 9].

High death rates have occurred in snailfarms all around Romania during the winter of the year 2006, proving that the standard outdoor hibernation technology is not well suited for colder climates (temperate continental climate). As a result, our research focused on finding some alternative paths for a proper hibernation of *H. aspersa* in colder climates. One solution was the development of "sandwich" system—a protective structure based on the nonconducting properties of the straw, on soil thermic inertia, and the insulator properties of nylon sheet. This system was tested at micropilot level in 2006 [9] and was extensively used in outdoor snailfarms [1]. However, two additional possibilities were also tested: indoor hibernation of *H. aspersa* juveniles and indoor rearing of *H. aspersa* juveniles during wintertime. It is known that during hibernation, the gastropods' vital functions decrease to subsistence level [10, 11] and the shell aperture is sealed with one or several epiphragms [12], allowing these terrestrial mollusks to survive in a stage of dormancy up to 4–6 months [13]. Indoor hibernation of mature snails, *H. aspersa*, in a controlled environment, temperature 2–6°C and humidity 70–80% [14], allows at least 80% of them successfully to pass overwinter [4]. We considered that indoor hibernation could represent a possible solution for *H. aspersa* juveniles, if this approach can be adapted for their physiological needs. The optimal survival level (Slo) of mature snails during hibernation (80%) was considered as a benchmark to assess the viability of this technology for *H. aspersa* juveniles. The experiments of this pilot exploratory study lasted 2 years and were performed in two distinct stages, in three snailfarms, and on 34,000 juvenile specimens of *H. aspersa* and 15,000 mature specimens of *H. aspersa*, using different technological flows and microenvironment parameters (temperature, humidity, and ventilation). Within the first stage, we conducted mixed experiments, using both mature snails and juvenile snails to evaluate the influence of technological flow and variable

microclimate parameters on the snails' intermediate survival rate (Sli) and final survival rate (Slf).

Then, we analyzed weight variation of *H. aspersa* juveniles during indoor hibernation (Wl, Wl%). The second stage assessed the viability of this novel approach before its extensive application, in relation to Slo and death levels of *H. aspersa* juveniles recorded during the first stage of our pilot exploratory study.

2. Materials and methods

The experiments of this pilot exploratory study were conducted in three snailfarms chosen based on their location, technological flow, and microenvironment parameters: Floreşti (Mehedinți county; latitude, 44°75'; longitude, 22°92'), Sântuhalm (Hunedoara county; latitude, 45°85'; longitude, 22°96'), and Muntenii de Sus (Vaslui county; latitude, 46°70'; longitude, 27°76'). The farms were carefully monitored since their implementation: 2005 (Muntenii de Sus) and 2006 (Floreşti, Sântuhalm). The reproductive herd was imported from Italy. The data were carefully monitored and recorded into technological evidence files. Next, they were used for five case studies (**Table 1**) depending on location and snail size: Cs1 (Floreşti, juvenile *H. aspersa* juveniles); Cs2 (Floreşti, mature *H. aspersa* snails); Cs3 (Sântuhalm, juvenile *H. aspersa* snails); Cs4 (Sântuhalm, mature *H. aspersa* snails); and Cs5 (Muntenii de Sus, juvenile *H. aspersa snails*). Field observations performed in 40 outdoor snailfarms from 2004 to 2007 indicated that, under Romanian pedoclimatic conditions, the mating season began in June, with most juveniles hatching in September. This does not allow the juveniles to exceed 1.0 cm in shell diameter till hibernation, and therefore, we considered that the snail size was homogeneous enough to provide accurate data. Moreover, before being hibernated, they were carefully selected by using a fine strainer (φ mesh = 1.15 cm). Thus, the term "juveniles" defines in this study young snails with shell diameter up to 1 cm. The indoor hibernation experiments monitored the survival levels of juvenile and mature specimens of *H. aspersa* in relation to three primary parameters: temperature, humidity, and ventilation (**Table 1**).

2.1 Hypothesis testing

First, two distinct locations were selected for these studies: Floreşti and Sântuhalm. Two lots were sampled from each location, one containing only juvenile *H. aspersa* snails and another only mature *H. aspersa* snails: Floreşti (Cs1, Cs2) and Sântuhalm (Cs3, Cs4). About 5 kg of juvenile *H. aspersa* snails were collected for each location. Five lots, about 100 g each (S_1–S_5), were aleatory collected for each location. Next, the number of juveniles was counted for each lot. Then, we estimated the individual average weight before hibernation (Wb) for each sample as the ratio between the total weight and the number of juveniles. After that, we estimated the number of hibernating juveniles (Nb) as the ratio between the total sample weight and Wb. During indoor hibernation, high death rates were recorded for juveniles, with each sample taken into account weighing after hibernation about 50 g. The individual average weight (Wa) and the number of juveniles for each sample (Na) after hibernation were assessed in the same manner as for before hibernation. Then, the survival level was calculated as the ratio (%) between Nb and Na. We also determined the weight loss during hibernation (Wl) for each sample as the difference between Wb and Wa. Then, the percentage weight loss (Wl%) was calculated as the ratio between Wl and Wa. For their mature

	Sampling data Number/(weight)	Intermediary control dead snails	Awakening (live snails)	T (°C)	U%	Ventilation
Cs1	November 17, 2006 5025 g (≈10,255 pcs.)	January 12, 2006	March 13, 2007 3670 juveniles	Constant 2–5°C	Variable 60–75%	Partially controlled
	Hibernation: Juveniles were introduced in a purging case (length, 100 cm; width, 100 cm; height, 25 cm), built from galvanized wire net (φ mesh = 0.3 cm), placed on a metallic frame, in a 5-cm-thick layer					
	Intermediary control: Snails were awaken from hibernation and fed with concentrated fodder and minced carrots					
	Microclimate: Undercroft, thermically insulated with extruded polystyrene, 5 cm thick • Temperature and humidity were constantly monitored by using two electronic thermohigrometers, no light					
	• Starting from January 12, 2007, a Ufesa VP3801 ventilator was installed. This ventilator, capable of gyratory movement to an angle of 80°, was used 5 days/weak and 2 hours/day					
Cs2	November 17, 2006 6500 pcs.	January 12, 2007 640 pcs.	March 13, 2007 5906 pcs.	Idem Cs1		
	Hibernation: Snails were introduced in a purging case (length, 80 cm; width, 80 cm; height, 30 cm) was built of galvanized wire net (φ mesh = 1.0 cm), placed on a metallic frame, in a 20-cm-thick layer					
Cs3	November 11, 2006 5050 g (≈12,949 pcs.)	January 1, 2007	March 7, 2007 724 pcs	Variable −1 → + 8°C	Variable 55–90%	Variable
	Hibernation: Hibernation in a cage (length = 100 cm, width = 100 cm, height = 25 cm), built of glass fiber net (φ mesh = 0.1 cm) placed on a wooden frame, previously disinfected with a 10% quick lime solution. Then, they were uniformly placed in layer, 3 cm in thickness, between two layers of straw, the upper one 3 cm thick and the lower one 5 cm thick					
	Intermediary control: January 1, 2007 **Microclimate**: Non-insulated outdoor storage, built of burnt bricks					
	• Temperature and humidity (50–85%) were constantly monitored by using two electronic thermohigrometers					
Cs4	November 11, 2006 8500 pcs.	January 1, 2007 2000 pcs.	March 7, 2007 5800 pcs.	Idem Cs3		
	Hibernation: Snails were introduced in a purging cage (length, 200 cm; width, 150 cm; height, 50 cm) built of glass fiber net (φ mesh = 1.0 cm), placed on an oak wood frame. Then, they were uniformly placed between two layers of straw, the upper one 15 cm thick and the lower one 10 cm thick					
Cs5	November 11, 2007 5, 050 g (≈10,100 pcs.)	—	March 18, 2008 6837 juveniles	Constant 2–5°C	Constant 70–75%	Controlled
	Hibernation: The juveniles were put in a multileveled structure, made up of three wooden boxes (length, 80 cm; width, 40 cm; height, 25 cm). To build the hibernation structure, the boxes were turn upside down, put one over another, and then covered on the side and lower part with a fine mosquito net **Microclimate**: Undercroft, thermically insulated with extruded polystyrene, 5 cm thick					
	• Temperature was constantly monitored by using two electronic thermometers. Air relative humidity was controlled with a humidifier Venta Airwasher LW 14 from 70 to 75%. A Ufesa VP3801 ventilator was used 7 days/week and 1 hour/day, to provide a proper aeration					

Table 1.
Indoor hibernation technological flow for the five case studies (Cs1–Cs5).

counterparts, only the intermediate and final survival levels were registered (Slf, Sli) as the percentage ratio between Na and Nb. The farms were monitored from September 2006 to April 2007, and all the data were carefully monitored and recorded in the technological evidence files (**Table 1**).

2.2 Technology optimization

The first stage data were used to optimize this technology in a study performed from October 2007 to March 2008 (**Table 1**) in a snailfarm located in Muntenii de Sus (Cs5). All the procedures were identical with those used in the study cases Cs1 and Cs3 (**Table 1**). The only exception was that the post-hibernal samples weighed about 75 g and not 50 g, like in the previous cases.

2.3 Statistical analysis

The hibernation efficiency (**Table 2**) was assessed based on the snail survival rate. To estimate the potential influence of origin and technological flow on juveniles' weight loss during wintertime (Wl), we analyzed all the quantitative indicators (individual weight, weight loss, snail number/known weight) by descriptive (**Figure 1**) and nonparametric statistical tests. First, we assessed the distribution normality (Anderson-Darling test) for Wb, Wl, Wa, Na, and Nb for all the samples (df = 1, n = 5/sample). After that, using a Kruskal-Wallis test with error Bonferroni correction (two-tailed, df = 2, n = 5/sample), we estimated Wb, Wa, Na, Nb, and Wl variations for juvenile snails (Cs1, Cs3, Cs5). Then, correlation analysis was performed to find whether these relationships between Wb and Wa displayed strong correlations among themselves. After that, we aimed to find the most appropriate function able to describe accurately these relationships. Thus, several attempts were conducted by using nonlinear regression. Finally, we chose the formulas that provided the highest precision (R^2) for all the samples taken into account.

	Cs1	Cs2	Cs3	Cs4	Cs5
Before hibernation					
Wb	0.49 ± 0.06	—	0.39 ± 0.06	—	0.50 ± 0.04
Nb	205.00 ± 25.77	—	262.20 ± 40.61	—	200.00 ± 14.98
After hibernation					
Wa	0.41 ± 0.04	—	0.31 ± 0.05	—	0.41 ± 0.03
Na	123.40 ± 14.77	—	160.80 ± 21.47	—	175.6 ± 24.82
Wl	0.087 ± 0.027		0.075 ± 0.023		0.089 ± 0.009
Wl%	16.33%		20.51%		18.00%
Intermediary control					
Sli	—	91.62%	—	76.46%	—
Dri	—	8.38%	—	23.53%	—
Final control					
Slf	35.78%	78.55%	18.06%	68.34%	67.69%
Drf	64.22%	21.45%	81.94%	31.66%	32.31

Table 2.
Descriptive statistics (mean individual weight, number/known amount, and weight loss during winter time; X ± SE, n = 5), weight loss (%), and survival parameters for the five case studies (Cs1–Cs5).

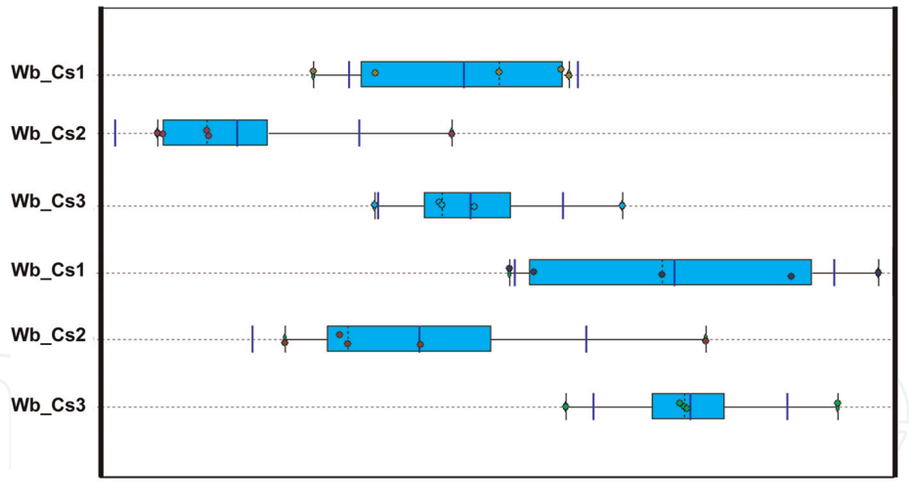

Figure 1.
Individual average weight (WA) variability.

Death rates were analyzed by using a χ^2 test (df = 1, two-tailed). To reduce the error in approximation, we adjusted χ^2 according to Yates' correction for continuity [15]. First, in 2007 we assessed the cumulated actions of size and technological flow on survival rate of *H. aspersa* juveniles during indoor hibernation in relation to mature snail mortalities (Cs1 vs. Cs2, Cs3 vs. Cs4). Next, we estimated the effect of technological flow on juveniles survival levels (Cs1 vs. Cs3). Then, we analyzed the impact of technological flow and microenvironment parameters on Slf and Sli for mature *H. aspersa* snails (Cs2, Cs4). After that, all the data were analyzed in relation to the optimal survival level for the indoor hibernation of mature snails, *H. aspersa* (80%). The results were used to adapt the indoor hibernation technological flow and to optimize it for the juvenile snails. These principles were put into practice for Cs5. Finally, in 2008 the survival level recorded in Cs5 was assessed in comparison to the juveniles' indoor hibernation attempts from 2007 (Cs1, Cs3). Before making a final conclusion, the Cs5 results were finally compared with Slo. Since this was a pilot exploratory study, no sample size calculation was needed.

3. Results

3.1 Hypothesis testing (Cs1–Cs4)

The Anderson-Darling test proved an abnormal distribution ($P > 0.05$) for all the quantitative parameters taken into account: mean individual weight, weight loss during hibernation, and snail number/known weight. Descriptive statistics (**Figure 1**, **Table 2**) revealed that before hibernation, Wb variability was almost equal for Cs1 and Cs3. In contrast, after hibernation Wa variability was higher for Cs3 (**Figure 1**, **Table 2**). Strong correlations between Wb and Wa are found for both Cs1 ($P = 0.013$; $R = 0.90$) and Cs3 ($P = 0.005$; $R = 0.95$). Irrespective of location, the Kruskal-Wallis test exhibited no significant influences ($P > 0.05$) of origin and indoor hibernation technological flow on Wb and Nb variation. Similar data were found for Wa, Na, and Wl variation ($P > 0.05$). In addition, the highest precision for correlations between Wa and Wb for both Cs1 and Cs3 was achieved by using a logarithmic regression described by the same base formula:

$$Wa = \mathrm{a}/\{1 + \log\ [-\mathrm{b} - (\mathrm{c} * Wb]\} \quad (1)$$

where *Wa* = mean weight after hibernation (g), *Wb* = mean weight before hibernation (g), and *a*, *b*, *c* = constant values (**Figure 2A**, **B**). The constants and the nonlinear correlation coefficients displayed the following values: Cs1 (R = 0.99; $a \approx 0.46$; $b \approx 7.21$; $c \approx 19.66$) and Cs3 (R = 0.82; $a \approx 0.46$; $b \approx 3.02$; $c \approx 2.49$).

The data recorded in the technological files revealed that, for Cs3 and Cs4, the problems started from January 1, 2007, when suddenly the outdoor temperature increased over 5°C and abundant rainfall (slushes) were recorded. Because the storage had no thermic insulation, the air humidity exceeded 85%, water condensated on the storage walls, the straw soaked, and the snails, especially the juvenile ones, started to awaken from hibernation. As a result, the straw were removed, and the dead snails were also drawn away. This action limited the death rate, but at the same time, it induced the restart of their metabolic cycle, especially for juvenile snails. This behavior of *H. aspersa* juveniles was attributed to their partial oblomovism. Under the same hibernation conditions, the size displayed a significant influence on Slf: Cs1 vs. Cs2 (χ^2 = 35.63, $P < 0.0001$) and Cs3 vs. Cs4 (χ^2 = 49.49, $P < 0.0001$). Different technological flows and microenvironment parameters (temperature, humidity, and ventilation) significantly influenced Slf for juvenile snails in Cs1 and Cs3 (χ^2 = 7.11, $P < 0.01$). Significant differences were also recorded regarding mature snails Slf (χ^2 = 7.47, $P < 0.01$) and Sli (χ^2 = 7.37, $P < 0.01$) in Cs2 and Cs4. Possible reasons were attributed to the cumulated effect of straw moistening, variable temperatures, and increased humidity. As a result, we eliminated from the technological flow the use of straw as hibernation support and considered unrecommended the fluctuation of microclimate parameters (temperature, humidity, and ventilation) inside the hibernation chamber. In addition, there seemed to be a positive relationship between snail size and tolerance to indoor hibernation.

At that time, no data were available in literature or in practice concerning the maximum period that allows juveniles to successfully survive during wintertime. Thus, Cs1 snails were awakened form hibernation on January 12, 2007. Next, they were fed with concentrated fodder and minced carrots, and after that, they were reintroduced to hibernation. After hibernation, the comparative statistical analyses revealed significant differences between Slf and Slo for the juvenile snails, in both locations: Cs1 (χ^2 = 38.31, $P < 0.0001$) and Cs3 (χ^2 = 74.23, $P < 0.0001$). Thus, it become obvious that during wintertime the juveniles must hibernate continuously, whereas their awakening and feeding must also be excluded from the technological flow. In addition, the higher survival rate and the lower Wb variability registered in Cs1 supported the idea that the technological used in this case represents the base for the future trials. In contrast, there were no significant differences in Slo between Cs2 (χ^2 = 0.01, $P > 0.05$) and Cs4 (χ^2 = 2.97, $P > 0.05$). These data confirmed mature snails' capacity to survive better during indoor hibernation than their younger counterparts. Although the Slf recorded for Cs2 and especially for Cs4 were lower

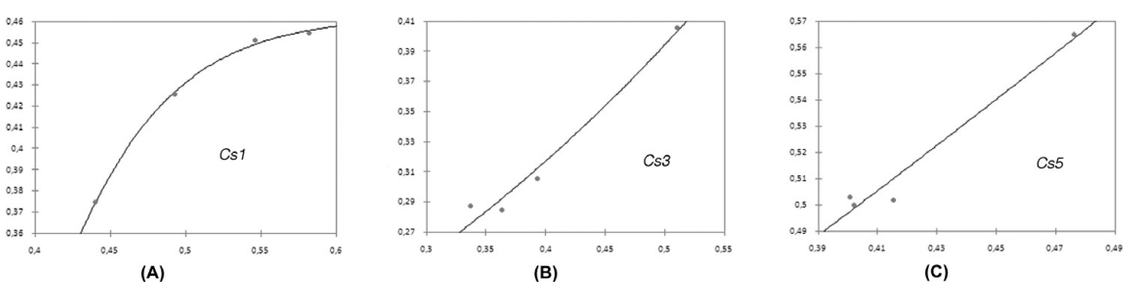

Figure 2.
Constant values (A, B, C).

than Slo, they were considered acceptable for indoor hibernation of mature snails, *H. aspersa*, considering that the microenvironment parameters were not totally identical with those used in the standard technology.

3.2 Technology optimization (Cs5)

The same abnormal distribution ($P > 0.05$) for all the quantitative parameters (mean individual weight, weight loss during hibernation, and snail number/known weight) was revealed for Cs5 (**Figure 1**, **Table 2**). Descriptive statistics (**Figure 1**, **Table 2**) revealed that Wa and Wb presented a lower variability for Cs5 than both Cs1 and Cs3. Correlation analysis showed that, similar to Cs1 and Cs3, there were strong correlations between Wb and Wa for Cs5 ($P = 0.004$; $R = 0.94$). Moreover, the Kruskal-Wallis test displayed no significant influences on Wb ($P > 0.05$) and Nb variation ($P > 0.05$). Similar results were also found for the nonparametric multiple analyses of Wa, Na, and Wl variation ($P > 0.05$). Moreover, the highest precision in estimating the correlation between Wa and Wb was achieved by using a logarithmic regression described by the same base formula as in Cs1 and Cs3 (**Figure 2C**). The constants and the nonlinear correlation coefficient displayed the following values: $R = 0.96$, $a \approx 1.33$, $b \approx 7.21$, and $c \approx 2.73$.

Concerning Slf, Cs5 proved significant differences in comparison to both Cs1 ($\chi^2 = 19.31$, $P < 0.0001$) and Cs3 ($\chi^2 = 48.02$, $P < 0.0001$). In contrast, no significant differences were found when Slf comparative analyses were performed in relation to Cs2 ($\chi^2 = 2.46$, $P > 0.05$) and Cs4 ($\chi^2 = 0.01$, $P > 0.05$). In addition, similar data were found in relation to Slo ($\chi^2 = 3.31$, $P > 0.05$). Moreover, weight loss overwinter in totally controlled condition (Cs5) presented a lower variability than for Cs1 and Cs3 (**Figure 1**). As a result, the technological flow followed in Cs5 was considered proper for indoor hibernation of *H. aspersa* juveniles because it provided the highest survival rate and the lowest weight variation during wintertime.

This study demonstrated without doubt that indoor hibernation of *H. aspersa* juveniles is a viable technology, which could be successfully used to improve the technological flow of outdoor snailfarming in colder climates. A successful implementation implies that microenvironmental factors (temperature, humidity, ventilation) are constant, whereas during hibernation the juveniles are not fed. However, mature snails seem to present a better tolerance to indoor hibernation; therefore this process must be more carefully controlled for the juvenile *H. aspersa* snails than for their mature counterparts.

4. Discussion

The key factors triggering land snail dormancy are temperature decrease [16], photoperiod diminishing [17], and low humidity [18]. For *H. aspersa*, extensive research proved that this process is controlled mainly by photoperiod [19], whereas temperature may determine its duration [20]. Although our experiments were conducted in the absence of light, regardless of size, the snails successfully hibernated for 100–110 days. However, we suggest that the cumulated actions of environmental factors (photoperiod, temperature, humidity) will easily induce snail hibernation than their simulation in a controlled microenvironment. As a result, to provide a successful indoor hibernation, the collection moment must be carefully chosen. Based on previous studies concerning *H. aspersa* prehibernal behavior in Romania pedoclimatic conditions [9], we considered that the proper moment to pick up the snails within the farm is early in the fall (September-October) when

there is a low day-night amplitude, the day length shortens below 10 hours, the temperature slowly and constantly decreases, and the soil humidity is moderate (<70%).

Oblomovism is well known in the world of mollusks [21]. This term came from the homonym novel written by Ivan Goncharov and is used to describe someone who exhibits the personality traits of sloth. Thus, during their life, snails pass through short periods of great activity, essential for building up their reserves, which alternates with frequent periods of inactivity, when they are sleeping or pending the favorable weather. Taylor [22] considered juvenile snails less sensitive to cold and thus less inclined to hibernation; therefore it was considered that they exhibit a partial oblomovism. However, recent studies proved that for *H. aspersa* freezing tolerance abilities vary converse with size [23]. This tendency was also noticed in our previous studies [9]. We suggested that this behavior has another more plausible explanation than the one proposed previously. Thus, the biological clock of juveniles *H. aspersa* is delayed as compared to their mature counterparts so they will start to hibernate later and will exhibit a long active cycle. Our studies also revealed that when temperature increased over the critical point of activity, +5°C for *H. aspersa* [24], this rule was also valid for indoor hibernation. The length of hibernation affects temperature-induced spermatogenic multiplication in *Helix aspersa* [25]. Additionally, a proper hibernation increases the reproductive activity and fecundity of *H. aspersa* [26]. As a result, a properly timed hibernation is a key factor in an outdoor snailfarm rentable gestion.

Our findings proved that juveniles displayed, regardless of the technology flow and origin, a relatively constant variation of weight after 100–110 days of indoor hibernation. Although in the wild, snails displayed variable losses of weight in relation to climatic factors [1], we considered that snail adaptation to hibernation throughout their long evolution and the controlled microenvironment allowed them to pass overwinter with a relatively constant weight loss during wintertime. Thus, we consider that this technology might be used in outdoor snailfarms located in colder areas with temperate continental climates as efficient alternative to the simple outdoor hibernation.

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