Influences of shading and hiding objects on the behavioral and productive performance of *Anguilla anguilla* elvers

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Abstract

Two hundred and fourty elvers were allotted into 16 groups; eight groups in shaded aquaria (aquaria wrapped with aluminum foil paper) and eight left without shading, from each eight aquaria four were supplied with hiding objects (three cylindrical plastic tubes) and the other groups kept without hiding objects. Each four groups subdivided according to the weight of elvers into small (1gm), medium (3g), large (5gm) and mixed size groups. This design was carried out for behavioral experiment and the same design was applied for productive traits but without combined shaded and hided groups to reduce the stress of weighing on the behavior of elvers.

Elvers were fed ad libitum commercial fish diet, daily water replacement with overnight stored water for regular cleaning of aquaria from uneaten food particles and fecal material. The behavioral observation was carried out by observer where the number of elvers engaged in each behavioral pattern within each aquarium was recorded. Elvers initial weight and weekly weighing was recorded, while, weight gain, specific growth rate were calculated. The survival rates of elvers in each aquarium were recorded at the end of the experiment. Obtained results would be summarized as:

1. Shading and hiding objects led to pronounced reduction in swimming activities and sporadic resting of elvers. On contrary, significantly increased colonization in hiding objects and group colonization. While, shading only without hiding objects increased sporadic resting on the floor of aquaria and reduce colonization to minimum level.
2. Small sized elvers exhibited significantly more swimming activities and less colonization activity than medium or large sized ones. However, mixing of different size of elvers within each other increased the swimming activity more than other groups, while, colonization activity was reduced.
3. Large sized elvers exhibited higher frequencies of colonization in all treatments while, low levels of swimming and sporadic resting was observed.
4. Elvers in shaded aquaria achieved higher body weights and specific growth rate while, those in aquaria without hiding objects or shading achieved the lowest body weight and weight gain. These differences were obvious throughout the experiment.
5. Although initial weight of elvers in all size weight groups was different the weight gain between different sizes was nearly the same while, the body weight and specific growth rate were significantly higher in large sized group followed by the mixed one.

6. Survival rates of elvers affected by treatment where, shading groups showed the highest survival rates while those kept in aquaria with hiding objects were the next, however, the lowest survival rate was observed for those kept without shading or hiding objects. Moreover, rearing large sized elvers achieved higher survival rates than medium or small sized elvers while, mixing small and large elvers reduced the survival rate to the lowest level.

Introduction

The European eel (*A. anguilla*) is a catadromous fish species that enters into the rivers from the sea at the so-called "glass" eel stage (i.e., transparent, mostly unpigmented fish). In the river, glass eels grow into the elver stage and pass through several stages of metamorphosis for 3 to 9 years, up to the "pubertal" yellow stage, when sex differentiation occurs *(Acou et al. 2003)*. After about 3 to 6 years more, they reach the adult silver stage and remain in the river for a variable period of time *(Walsh et al., 2004)*. Subsequently, adult fish return to their spawning area in the Sargasso Sea, where they reproduce and die; the resulting larvae return in a long migration to the European and North African coasts, where they metamorphose into glass eels *(Tesch, 2003)*. Currently, the European eel is a highly appreciated species in the food market, so fishing for eels is an important activity in most European countries. But due to the fishing effort, natural populations are overexploited and this effect together with other anthropogenic factors, such as loss of habitats, contamination, and transfer of parasites and diseases has contributed to the decrease in the captures of both glass eels and adults during the last 20 years *(ICES, 2005)*.

Developing aquaculture methods for the eel might reduce the fishery pressure and help to restock natural populations. However; the eel farming industry in Egypt is plagued by a serious problem, the most important problem facing eel culture in Egypt is that methods for controlling reproduction in captivity are lacking, so none or few viable larvae are obtained, the culture is thus dependant on a constant input of wild glass eels, but due to the variability of these natural stocks, the growth rates of glass eels during the first months of rearing in captivity are highly heterogeneous, which produces high dispersion in weight and length of the populations and favors elevated mortalities by cannibalism *(Gousset, 1990; Heinsbroek, 1991)*. Moreover, Glass eel capture, manipulation and transport to culture facilities is performed by fishermen using traditional methods during which not a great deal of care is taken in relation to fish health. The young fish are therefore exposed to high levels of stress during their capture and acclimation exacerbated by long periods of fasting, hypoxia and unsuitable water conditions, which can lead to high mortality, the development of pathological conditions or difficulties in weaning during the acclimation and pre-weaning phases.

Consequently; one of the most important processes in population ecology is an issue linking farming and behavioral features as, eels arriving from the sea use alternative migratory tactics, leading either to the colonization on rivers or to

an early settlement in marine or estuarine habitats. In the field, the migration may be environmentally affected by water temperature so the migratory behavior could be physiologically dependent on the body condition *(Edeline et al, 2006)*.

Moreover, due to their life cycle, the larval stage experience marine, estuarine and freshwater habitats and throughout their migration, they have to cope with oceanic, tidal and river currents, using either flow-carried or active swimming. Therefore; during the first four days after catching elvers hide in crevices, under stones etc. emerge only at night and show no interest of food, then begin feeding during the next 6 days *Usui (1999)*. This paper therefore seeks to study the effect of shading, and use of hiding objects on the behavioral patterns (colonization, swimming and resting), as well as productive performance and survival rates of elvers.

Material and Methods

Collection and transportation of elvers

Elvers or juvenile eels *A. anguilla*, were captured at late spring 2005, 10 km from the mouth of Rashid branch of Nile river, Rosetta line, Behara Governorate, Egypt. At this site fishermen usually collect eels at night by pushing a net during flood tide. On the following morning they pick up their capture. The elvers were then transferred in sealed plastic bags inflated with oxygen and containing a small amount of water collected from the point of capture to the Fish breeding and production laboratory, Animal husbandry and animal wealth development department, Faculty of veterinary medicine, Alexandria University, Egypt. The elvers were then arranged according to their individual body weight.

Experimental design:

To reduce the stress of weekly weighing on the behavior of elvers this study was carried out into two separate experiments as follows:

a. Behavioral experiment:

Elvers (n=240) were allotted into 16 groups in 16 of 300 liter rectangular glass aquaria filled with 240 liter dechlorinated tap water. Eight aquaria were wrapped with aluminum foil paper to give shade and to avoid direct exposure to light and other aquaria were left without wrapping. Moreover within each eight group four of them were supplied with hiding objects in the form of three cylindrical PVC tubes (10 cm length, and 5 cm inner diameter) and the other group kept without. All aquaria were supplied with air stones for continuous aeration.

For each group, the elvers were allotted according to their weight into small, medium, large and mixed sized groups. After weighting (80 small average 1 ± 0.2 gram, 80 medium averages 3 ± 0.2 gram and 80 large average 5 ± 0.2 gram), the elvers were allotted into groups according to the following design.

Elvers' size	Shaded aquaria		Non shaded aquaria	
	With hiding objects	Without hiding objects	With hiding objects	Without hiding objects
Small	15 Elvers	15 Elvers	15 Elvers	15 Elvers
Medium	15 Elvers	15 Elvers	15 Elvers	15 Elvers
Large	15 Elvers	15 Elvers	15 Elvers	15 Elvers
Mixed	5+5+5 Elvers	5+5+5 Elvers	5+5+5 Elvers	5+5+5 Elvers

The elvers were fed daily ad libitum (4% dry weight per fresh body weight) with a commercial diet that was manually hydrated to reach 80% of water content and ration was readjusted every 7 days. Water exchange was carried out daily with overnight stored water to get rid of chlorine during such time all aquaria were cleaned from unconsumed food and fecal material being removed moreover, the sides and floors of aquaria scrubbed and cleaned thoroughly.

The behavioral observation carried out by scanning observation by observer where the number of elvers engaged in each behavioral pattern in each aquarium was recorded then the percentage was calculated, moreover, in shaded aquaria a hole in the foil was made to facilitate observation.

b. Productive performance experiment:

Similar to behavioral experiment however, the treatments were only shaded aquaria, aquaria with hiding objects and control aquaria (without shade or hiding objects). Moreover, the elvers were initially weighed before allotting into groups then weekly weighing of the whole group was carried out. The weight gain and specific growth rates (SGRs), which were expressed as the percentage increase in body weight per day (%day^{1}), were determined by using the following formula:

$$SGR \quad \frac{LnWt - LnWo}{T} \quad X\ 100$$

Where: t = time in days (for percentage/day), $LnWo$ = natural logarithm of the average weight at time zero and $LnWt$ = natural logarithm of the average weight at time t.

Statistical analysis:

The behavioral data percentages were calculated then converted into Arcsine and analyzed by SAS (1990), using generalized linear models (GLMs), with following model:

$$y_{ijkl} = \mu + A_i + B_j + C_k + AB_{ij} + AC_{ik} + BC_{jk} + e_{ijkl}$$

Where: y_{ijkl}= an individual observation.; μ= overall mean; A_i = effect of i^{th} shading i.e. 1=shaded, 2=not shaded; B_j= Effect due to j^{th} hiding objects i.e. 1=with

hiding objects; and 2=without hiding objects C_k= effect due k^{th} elvers' size i.e. 1=small size, 2= medium size, 3=large size; and 4= mixed size group; AB_{ij}= effect due to interaction between shading and hiding objects; AC_{ik}=effect due to interaction between shading and size of elvers; BC_{jk}=effect due to interaction between hiding objects and size of elvers e_{ijkl}= random effect.

The body weight and weight gain were analyzed by SAS (1990), using generalized linear models (GLMs), analysis of covariance where the initial body weight was used as covariate with the following model:

$$y_{ijkl} = \mu + A_i + B_j + C_k + e_{ijkl}$$

Where: y_{ijkl}= an individual observation.; μ= overall mean; A_i =effect of i^{th} shading i.e. 1=shaded, 2=not shaded; B_j= Effect due to j^{th} hiding objects i.e. 1=with hiding objects; and 2=with hiding objects, C_k= covariance by initial elvers weight and e_{ijkl}= Random effect.

Results

Behavioral pattern:

Observations presented in Table (1) showed that elvers directly transferred from estuarine conditions of varying salinities to freshwater, and reared in shaded aquaria significantly increased colonization in hiding objects (18.82 vs. 12.92), total colonization (22.92 vs. 19.34) and sporadic resting (66.24 vs. 64.09). Swimming and bottom colonization, were higher in non shaded aquaria (10.85 vs. 16.58 and 4.10 vs. 6.41, respectively).

During this trial, presence of hiding objects in aquaria resulted in significantly higher total colonization (35.91 vs. 6.34), on contrary reduced bottom colonization (4.17 vs. 6.34), swimming (12.55 vs. 14.87) and sporadic resting (51.54 vs. 78.79). These results were observed under shading system with higher total colonization (40.79 vs. 5.04) and lower bottom colonization, swimming and sporadic resting (4.17 vs. 6.34; 12.55 vs. 14.87 and 51.35 vs. 81.12, receptively) whereas the non shaded system showed higher total colonization (31.04 vs. 7.64) and lower bottom colonization, swimming and sporadic resting (5.19 vs. 7.64; 15.25 vs. 17.90 and 51.72 vs. 76.46, respectively).

The elvers' size colonization under hiding objects was observed to be increased with age (Table 1) where the smaller elvers showed the lowest colony formation in hiding objects (13.66) than medium sized (15.67) or large sized elvers (23.425), however, when different sizes were mixed with each other they behaved similar to the medium sized elvers (15.75), similarly total colonization showed the same trend (18.14 vs. 20.48 and 28.87, respectively). As the younger elvers had lower experience than older one, they exhibited higher sporadic resting (69.03) than medium (66.50) or larger sized elvers (63.37).

Within different systems of rearing, elvers size had highly significant effect on the colonization in hiding objects either in shaded or non shaded system. However, lower incidences were observed in small sized elvers (15.16 and 12.17), medium (16.14 and 15.21) and large sized ones (18.86 and 25.71), respectively, while, colonization on bottom and total colonization were not affected significantly within the different group size of elvers (Table, 1).

Swimming activity of elvers under shade system was correlated with their size. Smaller elvers exhibited much swimming activities in shaded and non shaded system (15.43 and 10.23, respectively) than larger sized ones (9.30 and 6.23), respectively), although however, this difference was not significant. The mixing of the different sized elvers' seed in the same aquarim resulted in average activity values either in colonization in hiding objects or total colonization although however increased swimming activity (31.56) and reduced sporadic resting (55.83).

Not only colonization in large size elvers in hiding objects were significantly higher (46.84) than medium (31.35) and small sized elvers (27.33) but also total colonization (48.12 vs. 33.67 and 28.58, respectively). Also, without hiding objects total colonization higher in large sized than medium and small sized elvers (9.62 vs. 7.30 and 7.71, respectively). The presence of the hiding objects in aquaria resulted in low swimming activity than elvers in aquaria without hiding objects for small (12.49 vs. 13.17), large (7.24 vs. 8.29) or mixed elvers (13.93 vs. 28.54). Similarly the sporadic rest was lower in elvers with hiding objects than those without hiding objects.

Productive performance:

a. Body weight:

A. anguilla elvers reared in shaded aquaria accepted the commercial eel diet more readily and grew faster over 28 days than eels than those reared in aquaria containing hiding objects although (Table 2a), however, the rearing in aquaria containing hiding objects improve body weight than those without hiding objects or shade after 7 days (3.58 vs. 3.56 and 3.35 gm, respectively), 14 days (4.23 vs. 3.93 and 3.68 gm, respectively), 21 days (4.86 vs. 4.58 and 4.18, respectively) and 28 days of rearing (5.63 vs. 5.38 and 5.15 gm, respectively).

Analysis of variance of the effect of size of elvers' seed on body weight showed that elvers' seed continued to grow under the experimental conditions in aquaria with nearly the same difference between all group sizes (Table 2a).

b. Weight gain:

Analysis of variance of the weight gain data showed significant difference (Table 2b) where elvers kept in shaded condition or those reared in aquaria containing hiding objects showed better weight gain during 1st week of the experiment (0.57 and 0.60 vs. 0.34 gm, respectively) 2nd week (0.67 and 0.35 vs. 0.00 gm, respectively) and total weight gain throughout the experiment (2.62 and 2.39 7 vs. 2.15 gm, respectively). Fingerling's size was observed to be of no

significant effect on the weight gain in all groups through out the experiment and on total weight gain.

c. Specific growth rate:

During the present study, specific growth rate was highly variable (Table, 2c & Fig, 1). Specific growth rate of aquaria shaded elvers was significantly higher than those in aquaria with hiding objects or without shade or hide during the 1st week after stocking (102.87 vs. 104.40 and 96.67, respectively) and this difference continued during the 2nd week (120.08 vs. 113.16 and 106.23, respectively), 3rd week (135.01 vs. 129.10 and 120.15, respectively) and 4th week (147.62 vs. 143.67 and 140.09, respectively).

Not only treatment of aquaria that affected the specific growth rates of the elvers but also the initial weight or the stocking density (kg/Liter) where heavy stocking resulted in significantly higher specific growth rates (Table 2c) during all weeks of the experiment while the mixed group takes the 2nd position after large sized group for specific growth rate.

d. Survival rate:

At termination of the trial, elvers reared under shaded condition had significantly higher survival rate (73.35%) followed by those in aquaria with hiding objects (68.33%) and the lowest survival rates observed in aquaria without shade or hiding objects (59.99%). Moreover, large sized elvers' size had high survival rates (75.55%) than medium (68.89 %) or small sized elvers (64.44%), although however, mixing of small size with large size elvers resulted in lowest survival rate (60.67%).

Discussion

Japanese eel farmers originally included an acclimation period with a salinity slowly decreased, but now prefer to transfer glass eels directly into freshwater *(Gousset 1990)*. Moreover; *Ingram, et al. (2001)* showed that current practice in the European intensive eel farming industry did not include an acclimation period to freshwater for newly caught *A. anguilla* glass eels; however, emphasis is placed on obtaining glass eels of a high quality (physical condition and health). Our study is a pioneer report discussing the eel behavioral pattern under captivity, just after transporting from the salinity to fresh water and the effects of shading and use of hiding objects on these behavioral patterns and consequently on the productive performance and survival rates of juvenile eels.

Studying behavioral pattern revealed that presence of shading and hiding objects in the glass aquaria resulted in significantly higher total colonization of elvers. On the contrary; swimming activity and bottom colonization was reduced. This could be attributed to strain applied on the fish during catching and transportation which leads to much resting and hiding in hiding objects. Similarly *Usui (1999)* concluded that elvers hide in crevices, under stones etc., for the first

four days after catching, emerge only at night and show no interest of food, then begin feeding during the next 6 days. However, this behavior was attained by elvers reared in shaded aquaria with or without hiding objects during the rest of this experiment and consequently reduced aggressive behavior between tank-mates *(Kushnirov and Degani, 1991)*. Moreover, starved fish showed a marked reduction in swimming activity, and often hid inside the cylindrical tubes in the bottom of the tanks showing signs of lethargy. No evidence of external lesions, or bite marks from aggressive behavior amongst elvers was detected, although cannibalism was observed in larger fish that ate moribund or dead specimens *(Rodríguez, et al., 2005)*

Swimming activity of the elvers seed under shade system was linearly correlated with age and size of the elvers where the swimming activity were higher in smaller elvers either in shaded or non shaded system than larger ones; respectively, although however, this difference was of non significant value this could be attributed to the built-in information of these small elvers to reach suitable places for completing this stage of life *(Walsh et al., 2004)*.

Mixing of different size elver's seed in the same aquaria resulted in average activity values either in colonization in hiding objects and total colonization. On contrast they increased their swimming activity and reduced sporadic resting. This might be attributed to cannibalistic activity of large sized elvers toward the small sized ones as these creatures favorite natural food than formulated ration during this stage of life. Similar results were obtained by *Ingram, et al. (2001)* who stated that from preliminary observations made prior to commencement of the study indicated that Artemia or minced fish flesh may be suitable diets for the initial feeding of newly caught glass eels of *A. australis* in captivity, to stimulate active feeding at weaning and before attempting to change to an artificial diet. Moreover, behavior that depended on the density treatment might lead to different life strategies where fish maintained at low surface density became territorial, gregarious, and less active, whereas fish at high density lacked the space for a proper habitat and became active swimmers, which could enhance aggressive behavior and stimulate the intake of food or the food conversion ratio *(Huertas and Cerda, 2006)*.

A significant improvement of growth performance including more body weight, weight gain, specific growth rates and high survival rates was attained in elvers reared in shaded aquaria with or without hiding objects associated with high surveillance. These results seemed to be a direct output of the prevention of aggressive interaction between aquaria-mates as reported by *Kushnirov and Degani, (1991)*. Moreover, reduction in swimming activity of elvers reared in shaded aquaria with or without hiding objects might also contribute to reducing their metabolic costs, sparing energy requirements and so the observed increase in their weight gain, as those been observed in other fish species *(Blaxter and Staines, 1971)*.

Different sized elvers' seed continued to grow under the experimental conditions with nearly the same gain although however, younger sized one showed low survival and specific growth rates. These results indicate the importance of having elvers in good physical condition and health for weaning, and the efficient use of these eels through maximizing survival during acclimation and subsequent weaning. On contrary, *Ingram, et al. (2001)* reported that, initial stocking densities, did not significantly affect either the growth or survival of juvenile *A. australis*. While *Heinsbroek (1991)* reported that in Europe, the *A. anguilla* are initially stocked into tanks on-grown at higher densities. The mechanism by which density may affect growth is still uncertain, although several authors have suggested that social interactions play a role in such mechanism *(Devlin and Nagahama, 2002).*

From the previous results it could be concluded that farming of eels in aquaria with shaded areas or with adding hiding objects such as plastic tubes give an advantage for eels to rest by encouraging their groupings and so reduce swimming activity which leads to spare body energy and so reflected in higher body weight, weight gain and specific growth rate. Moreover, in grouping elvers' it is preferable to rear elvers of even size together to prevent chasing of young ones with older one which leads to reduction in body weight, weight gain, specific growth rate and survival rates.

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Table (1): Effect of elvers' size, hiding objects and shading on some behavioral traits.

Item		Colonization in			Swimming	Sporadic resting
		Hiding objects	Bottom	Total		
Shading						
Shaded		18.82±2.84^{a}	4.10±1.19	22.92±2.97	10.85±1.20^{b}	66.24±2.48
Without shade		12.92±2.52^{b}	6.41±1.49	19.34±2.58	16.58±2.38^{a}	64.09±2.75
Hiding objects						
With Hiding object		31.75±2.59^{a}	4.17±1.35	35.91±2.61^{a}	12.55±1.97^{b}	51.54±2.06^{b}
Without Hiding object		0.00±0.00^{b}	6.34±1.35	6.34±1.35^{b}	14.87±1.85^{a}	78.79±1.90^{a}
Shading*Hiding objects						
Shade with hide		37.64±3.14^{a}	3.15±1.32	40.79±3.35^{a}	7.85±1.43	51.35±2.51
Shade without hide		0.00±0.00^{b}	5.04±1.98	5.04±1.98^{b}	13.84±1.80	81.12±2.09
Not shade with hide		25.85±3.89^{a}	5.19±2.35	31.04±3.86^{a}	15.25±3.50	51.72±3.30
Without Shade or hide		0.00±0.00^{b}	7.64±1.85	7.64±1.85^{b}	17.90±3.26	76.46±3.16
Size						
Small		13.66±2.72^{c}	4.48±1.34^{b}	18.14±2.54^{bc}	12.83±1.60	69.03±2.83^{a}
Medium		15.67±3.26^{b}	9.81±2.88^{a}	20.48±4.16^{b}	13.01±3.52	66.50±4.15^{ab}
Large		23.42±5.12^{a}	5.45±1.76^{b}	28.87±4.79^{a}	7.76±1.36	63.37±4.33^{b}
Mixed		15.74±3.55^{b}	1.28±0.73^{c}	17.01±3.72^{c}	21.24±3.17	61.75±3.31^{b}
Shading*size						
Shaded	Small	15.16±4.33^{ab}	4.04±1.89	19.19±4.38	15.43±2.36	65.37±3.99^{ab}
	Medium	16.14±5.59^{ab}	9.25±3.87	29.39±6.03	7.74±1.87	62.87±5.33^{ab}
	Large	21.12±7.24^{a}	0.54±0.54	21.67±7.29	9.30±2.28	69.04±6.11^{a}
	Mixed	18.86±5.60^{ab}	2.56±1.41	21.42±5.93	10.92±2.78	67.66±4.50^{ab}
Without	Small	12.17±3.38^{c}	4.92±1.96	17.09±2.70	10.23±2.04	72.68±3.92^{a}
	Medium	15.21±0.93^{bc}	10.38±4.39	11.58±4.96	18.29±6.63	70.13±6.40^{a}
	Large	25.71±7.42^{a}	10.36±3.05	36.07±5.89	6.23±1.46	57.69±5.98^{b}
	Mixed	12.61±4.42^{c}	0.00±0.00	12.61±4.42	31.56±4.43	55.83±4.52^{b}
Hiding objects*size						
Hided	Small	27.33±2.37^{b}	1.25±0.25	28.58±2.76	12.49±1.64^{b}	58.93±2.62
	Medium	31.35±5.37^{b}	12.33±4.53	33.67±5.95	16.54±6.63^{b}	49.79±4.89
	Large	46.84±5.93^{a}	1.28±0.88	48.12±5.96	7.24±2.18^{b}	44.65±4.57
	Mixed	31.47±4.38^{b}	1.82±1.27	33.29±4.63	13.93±3.24^{b}	52.77±3.52
Without	Small	0.00±0.00^{c}	7.71±2.12	7.71±2.12	13.17±2.81^{b}	79.12±3.56
	Medium	0.00±0.00^{c}	7.30±3.60	7.30±3.60	9.48±2.35^{b}	83.22±3.14
	Large	0.00±0.00^{c}	9.62±3.12	9.62±3.12	8.29±1.69^{b}	82.08±3.12
	Mixed	0.00±0.00^{c}	0.74±0.74	0.74±0.74	28.54±4.89^{a}	70.72±4.71
S.O.V.		Mean square errors				
Shading		1113.21**	172.14	1050.19	3488.01	409.84
Hiding		32247.84**	150.95	172.52	23763.64**	27986.23**
Shade*Hiding		1113.21**	2.50	430.12	201.80	1221.29
Size of elvers		2844**	1190.98*	2984.86**	1011.78	2757.49*
Shade*Size		2307.66**	667.29	3540.53	2850.15	4441.22**
Hiding*Size		2844.00**	951.56*	1946.26**	2226.94**	1395.77
Experimental error		16772.34	11686.22	19485.77	25271.44	24590.08

Means within the same column under the same item carry different superscripts are significantly differ

* Significant difference at level (P≤0.05) ** Highly significant difference at level (P≤0.01)

Table (2a) Least square mean and their standard error of the effect of treatment and elvers' size on the body weight.

Item	7 days	14 days	21 days	28 days
Treatment				
Shaded	3.58±0.88	4.23±0.93^{a}	4.86±0.75^{a}	5.63±0.79^{a}
Hided	3.56±0.88	3.93±0.83^{ab}	4.58±0.79^{ab}	5.38±0.82^{ab}
Control (without)	3.35±0.80	3.68±0.82^{b}	4.18±0.77^{b}	5.15±0.84^{b}
Size of elvers				
Small	1.50±0.06^{c}	2.03±0.12^{c}	2.97±0.29^{c}	3.57±0.23^{c}
Medium	3.30±0.06^{b}	3.67±0.07^{b}	4.07±0.15^{b}	5.20±0.06^{b}
Large	5.67±0.19^{a}	6.20±0.26^{a}	6.62±0.22^{a}	7.53±0.15^{a}
Mixed	3.57±0.03^{b}	3.87±0.20^{b}	4.50±0.21^{b}	5.23±0.15^{b}
S.O.V.	Mean square error			
Treatment	0.029	0.178**	0.257*	0.134*
Size of elvers	0.081	0.264**	0.424**	0.189**
Initial weight	0.001	0.021	0.041	0.044
Experimental error	0.020	0.010	0.038	0.021

Table (2b) Least square means and their standard error of the effect of treatment and elvers' size on the weight gain.

Item	0-7 days	7-14 day	14-21 day	21-28 day	Total gain
Treatment					
Shaded	0.57±0.08	0.67±0.10^{a}	0.62±0.24	0.77±0.13^{b}	2.62±0.18^{a}
Hided	0.60±0.12	0.35±0.06^{b}	0.64±0.07	0.81±0.08^{b}	2.39±0.07^{b}
Control (without)	0.34±0.06	0.33±0.10^{b}	0.49±0.12	0.98±0.13^{a}	2.15±0.06^{b}
Size of elvers					
Small	0.50±0.06	0.53±0.09	0.93±0.19	0.60±0.06^{b}	2.57±0.23
Medium	0.50±0.06	0.37±0.03	0.40±0.15	1.13±0.09^{a}	2.50±0.06
Large	0.67±0.19	0.53±0.20	0.42±0.10	0.92±0.09^{a}	2.53±0.15
Mixed	0.55±0.04	0.34±0.18	0.59±0.06	0.76±0.07^{ab}	2.53±0.14
S.O.V.	Mean square error				
Treatment	0.057	0.158*	0.037	0.028*	0.125*
Size of elvers	0.169	0.070	0.061	0.315**	0.025
Initial weight	0.001	0.114s	0.027	0.000	0.041
Experimental error	0.020	0.018	0.070	0.009	0.021

Means within the same column carry different superscripts are significantly differ

* Significant difference at level (P≤0.05) ** Highly significant difference at level (P≤0.01)

Table (2c) Least square mean and their standard error of the effect of treatment and elvers' size on the specific growth rate (%day^{1}).

Item	0-7 days	7-14 day	14-21 day	21-28 day	Survival rate
Treatment					
Shaded	102.87±23.21^{a}	120.08±18.91^{a}	135.01±11.61^{a}	147.62±11.68^{a}	73.35+6.09
Hided	104.40±22.12^{a}	113.16±18.05^{b}	129.10±14.00^{ab}	143.67±13.15^{ab}	68.33+8.33
Control (without)	96.67±23.00^{b}	106.23±20.11^{c}	120.15±15.25^{b}	140.09±14.25^{b}	59.99+4.71
Size of elvers					
Small	40.40±3.85^{d}	64.83±5.66^{c}	97.70±8.93^{c}	111.34±5.09^{c}	64.44+8.01
Medium	103.67±1.75^{c}	112.85±1.59^{b}	121.60±3.57^{b}	144.83±0.60^{b}	68.89+8.89
Large	150.36±3.33^{a}	157.51±3.93^{a}	162.81±2.81^{a}	174.92±1.47^{a}	75.55+9.60
Mixed	110.83±1.14^{b}	117.43±5.41^{b}	130.23±3.69^{b}	144.07±1.95^{b}	60.67+3.85
S.O.V.	**Mean square errors**				
Treatment	134.17**	383.23**	447.7*	113.42*	181.59
Size of elvers	18635.36**	12962.25**	6526.06**	6069.07**	132.07
Exp. error	47.44	92.46	236.86	80.25	191.35

Means within the same column carry different superscripts are significantly differ

* Significant difference at level (P≤0.05) ** Highly significant difference at level (P≤0.01)

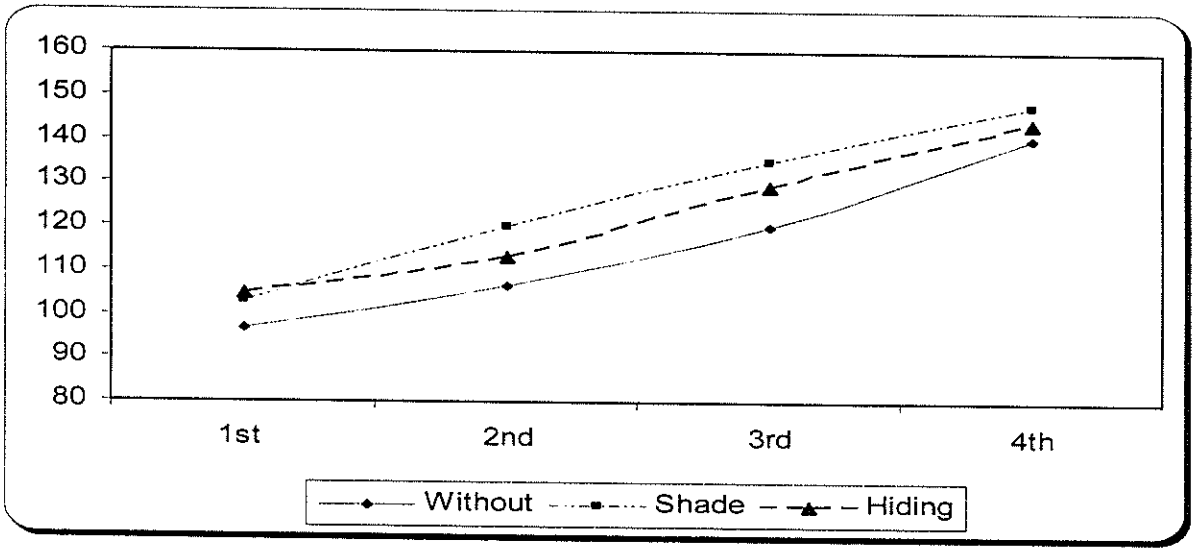

Fig. (1) Effect of aquaria treatment on the specific growth rate of the elvers during the experimental period.

الملخص العربى

وأماكن الإختباء على السلوكيات والكفاءه الأنتاجيه لثعابين السمك

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يعتبرالأستزراع السمكى للثعابين من أحدث المشروعات الإنتاجيه فى العالم وفى مصر خاصه وتحتاج الى الكثير من الدراسات البحثيه فى أقلمه وأستزراع الثعابين تحت الظروف البيئيه المصريه ولذلك أجريت الدراسه كمحاوله لمعرفه بعض ظروف الأستزراع التى يمكن تطبيقها فى مزارع الأسماك المختلطه أو التى تستعمل لتربيه الثعابين خاصه حيث تهدف الدراسه الى أضافه أماكن ذات ظل أو أضافه أماكن تختبئ بها الثعابين وذلك لتوفير ظروف مشابهه للظروف الطبيعيه وتم تقييم ذلك بمراقبه سلوكيات هذه الأسماك حيث تم تقسيم عدد ٢٤٠ زريعه ثعبان السمك الى سته عشر مجموعه قوام كل مجموعه ١٥ ثعبان فى أحواض زجاجيه سعه كل حوض ٢٤٠لتر ماء وتم تغليف ثمانيه أحواض بورق الألومنيوم لتجنب التعرض المباشر للضوء والثمانيه مجموعات الأخرى تركت معرضه للضوء وتم وضع ثلاث أنابيب بلاستيكيه فى أربعه أحواض من كل مجموعه وذلك لتوفير أماكن لأختباء للثعابين و لقياس وعدلات نموها ومعدلات الحياه أجريت تجربه أخرى ولكن قسمت الثعابين فيها الى ثلاث مجاميع بدون الجمع بين الظل وأماكن الأختباء٠

تم تغذيه الثعابين على علائق تم تصنيعها من مسحوق السمك وكذلك تم تغير جزء من مياه الأحواض يومياً ومد الأحواض بتيار هواء وذلك لتزويدها بالأوكسجين٠ لوحظت سلوكيات الثعابين عن طريق عمل فتحات فى جانب الحوض لمعرفه عدد الثعابين فى كل مكان والتى تسبح منها وكذلك تم وزن الأسماك قبل التجربه وتقسيمها على اساس الوزن الى أربعه مجموعات صغيره ومتوسطه وكبيره ومجموعه مختلطه الوزن٠ وأظهرت النتائج مايلى:

١. أحدث تظليل الأحواض وأضافه أماكن الأختباء الى خفض معدلات السباحه وزياده معدلات التجمعات على نظام مستعمره سمكيه فى الأحواض الى أعلى معدلاتها بينما كان أعلى معدل سباحه فى الأحواض عديمه الظل وأماكن الأختباء كذلك أدى تظليل الأحواض بدون وضع أماكن الأختباء الى زياده معدل السكون الفردى للثعابين على أرضيه الحوض وتقليل التجمعات الى أقل معدل لها٠

٢. كان لحجم الثعابين تأثيرات معنويه على سلوكياتها فقد حققت الثعابين الصغيره أعلى معدل سباحه وأقل معدل لتكوين تجمعات عن تلك المتوسطه والكبيره ٠ بينما أدى خلط الثعابين الصغيره مع الكبيره الى زياده معدلات السباحه فى المجموعه ويرجع ذلك الى مطارده الثعابين الكبيره للصغيره حيث تفضل هذه الثعابين فى تلك الفتره من العمر الغذاء على الحى على العلف المصنع وعلى النقيض من ذلك أنخفضت التجمعات فى هذه المجموعه عن المجموعات الأخرى أنخفاضاً معنوياً٠

٣. أظهرت مجموعات الثعابين الكبيره معدلات أعلى فى التجمعات داخل أماكن الأختباء والتجمعات الكليه وأقل معدلات سباحه وكانت معدلات اللأستراحه على أرضيه الحوض أقل مستوى ممكن٠

٤. كانت الثعابين فى مجموعات الأحواض الغير متعرضه للضوء ذات معدلات وزن أكبر تبعتها تلك التى فى الأحواض عديمه الظل ولكن بها أماكن للأختباء وكان أقل معدل زياده فى الوزن فى المجموعات التى تعرضت مباشره للضوء بدون وضع أماكن للأختباء وذلك فى جميع الأوزان من الأسبوع الأول وحتى نهايه التجربه كما تمتعت هذه المجموعات بأعلى زياده فى الوزن ومعدل الزياده فى الوزن والوزن النوعى ذو قيمه عاليه المعنويه فى المجموعات ذات الظلال عن المجموعات ذات اماكن أختباء أو تلك المتروكه بدون ظل أو أماكن أختباء٠

٥. على الرغم من اختلاف وزن المجموعات فى بدايه التجربه والذى بدا واضح التأثير طوال مده التجربه داخل المجموعات المختلفه إلا أن معدل الزياده فى الوزن داخل المجموعات كان متساوياً بينما معدل الزياده النوعيه كان أعلى مايكون فى المجموعه الكبيره تبعتها المجموعه المختلطه٠

٦. تأثرت معدلات البقاء للثعابين تأثراً واضحاً بالمعاملات حيث كان أعلى معدل بقاء فى الأحواض التى تم تظليلها ثم تبعتها الأحواض التى بها أماكن للأختباء وكانت أقل نسبه فى الأحواض التى تركت بدون ظل أو أماكن للأختباء٠ وكذلك كان معدل البقاء أعلى مايكون فى الثعابين الكبيره بينما كان أقل مايكون فى المجموعه المختلطه٠

٧. ونخلص من ذلك أن تربيه الثعابين فى أحواض ذات ظلال أو أماكن أختباء يقلل من الجهد المبذول فى السباحه وبالتالى يوفر الطاقه وهذا ينعكس عليها فى زياده وزن الثعابين ومعدلات نموها بينما الخلط بين الأحجام المختلفه من الزريعه يؤدى الى زياده المطارده بين الثعابين وأنخفاض الوزن، الوزن المكتسب، معدل النمو المكتسب ومعدلات الحياه-