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The secondary productivity and some reproductive notes on Limnodrilus hoffmeisteri (Claparede, 1862) (Oligochaete: Naididae: Tubificinae) productivity in Shatt Al-Arab River, Basrah, Iraq

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ABSTRACT

Limnodrilus hoffmeisteri is an oligochaete belongs to the Tubificidae family, inhabiting fresh water. It is a common benthic species in the Shatt al-Arab. Samples were collected from twice a month from Shatt Al-Arab River near the confluence of the Ribat River for the period during the period September 2012 to August 2013. The collection was carried out using a cylindrical core with an area of 78.5cm². The weight of adult *L. hoffmeisteri* that carry eggs ranged from 0.140 to 0.439 mg. Maximum length of the species (13.03 mm), dry weight (0.577 mg,) and biomass (2.944 g / m²) were recorded. Annual yield of the biomass (11.801 g / m²), instantaneous growth rate (0.107 g / m² / year) and productivity (0.1592 g / m² / year)were calculated. The species was reared in the laboratory under three different temperature and three different diets. Feeding on oats resulted in higher growth rate while salary lead to earlier maturation.

Keywords: benthos, secondary productivity, adult worms, wet weight.

Introduction

Annelids are a widely distributed invertebrates. The phylum comprises approximately 12,400 species characterized as vermiform and have chaetae or setae. They also have a thin body and consist of a series of similar rings forming what is known as metamerism. The thin moistened epidermis plays an important role in the movement and respiration, which indicates the need of the annelids to inhabit wet habitats and cannot tolerate drought (Thorp and Covich, 1991). **Oligochaete** are decomposers that play an important role in energy transfer through in food chain and recycling resources (Risnoveanu and Vadineanu, 2003). Authors who study the secondary productivity of benthic groups often use an annual reversal rate of ≤ 10 (Lindegaard, 1992; Smock et al., 1992) while Waters (1977) suggested a reverse annual rate of oligochaete equal to 10, where the secondary productivity of benthic invertebrates is calculated by calculating annual turnovers rates. The annual conversion rate P/B of the species: *Chaetogaster diastrophus* and *Nais* spp. and *Stylaria lacustris* were 108, 96 and 78, respectively. As noted from the field results of Lake Belau in Germany, there is a lack of nutrient level in the lake when the Naididae family reached the peak of abundance and presence, which did not pour all its propagation efforts throughout the whole season (Löhlein, 1999).In spite of the importance of studying oligochaete productivity, there are no accurate results obtained in this regard (Brinkhurst, 1970), as the study of productivity is usually faced with the difficulties of determining the age of individuals and changes in the life history during the seasons of the year. Ivlev (1939) overcame this problem by calculating the growth and food energy shortage as it passed through the digestion channel. It has been found that the high growth rates obtained during the studies were because the worms prefer to dilute sediments that reach the water limit to 93% but this conclusion should not be applyed to what exists in the environment (Brinkhurst *et al.*, 1972). The aim of this study is to estimate the secondary productivity of the species *L. hoffmeisteri* and the effect of temperature on the hatching of the cocoons.

Materials and Methods

Samples of *L. hoffmeisteri* were collected bimonthly from the bank of Shatt Al-Arab at for the period September 2012 to mid-August 2013(Fig.1), using a 10 cm diameter core and 3 cm height. Samples were placed in plastic bottles with a 10% formalin.

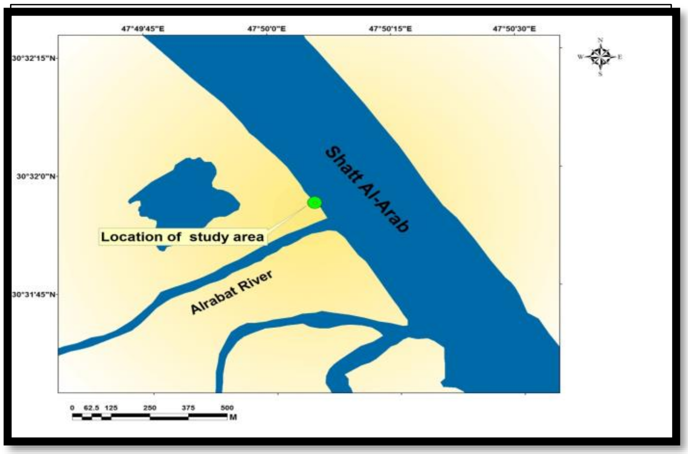

Fig1:The Location of study

At laboratory, samples were screened by a 400 micrometer sieve and worms were collected using forceps. Worm lengths were measured using an anatomical microscope at a magnifying lens of 1.5x to the nearest millimeter. Weights were recorded (to the nearest milligram) using a sensitive balance of Cahn microbalance. 92 individuals of *L. hoffmwisteri* were used to calculate Length-weight relationship. Individuals were dried at 60 ° C for 24 hours for dry weight measurement.

The linear regression equation $y = a + bx$ (where y = animal weight, x = animal length and a, b constant) was used to estimate animal weights every half a month and calculate the biomass.

Soil samples were collected from the site for soil texture**.** Malvern mastersizer 2000 instrument was used to identify soil texture after screening and calculating the gravel (≥2mm) percentage

The instantaneous growth rate was calculated by using the equation after . (Lochhead and Learner, 1983; Smith, 1986).:

r= (ln Nt – ln N0)/t

r: The instantaneous growth rate.

N: Individual number.

t: Time

The secondary production: was calculated by using the equation after (Johnson and Brinkhurst ,1971):

$p = r * \vec{B}$

p: Productivity.

B: Biomass.

Soil from the site was used after sterilization and sieving by 65-micrometer mesh sieve for hatching and growth experiments. This soil was moisture by 100 ml of water and kept in a 250 ml beaker. Mature worms were chosen and five of them were placed in the beaker containing moisture soil after being weighted. We used five replicates for each incubation temperature Addition amounts of water was added when needed. Beakers were kept in incubators at temperatures of 10,15, 20 and 25 °C. The average biomass of *L. hoffmeisteri* in Shatt Al-Arab was between 0.034 and 2.94 g / m²,

Results

Bottom nature:

The analysis of the soil sample showed a sandy bottom consisting 88% sand, 9% gravel and 3% silt, while the organic content in June 2013 was 6.97%.

Length-Weight Relationship:

There was a positive correlation (R^2 = 0.8042) between lengths and weights of *L. hoffmiesteri* individuals sampled. Length-weight relationship (fig. 3) is represented by the equation:

y= 0.014x - 0.069

y = Weight (mg)

x = Length (mm)

In addition to the funnel shape penial (fig.4) that distinguishes members of this species (x = 40), (Brinkhurst and Jamieson, 1971).

Density and individual number:

The highest density of *L. hoffmeisteri* was recorded in June, reaching 22225 individuals /m^2, while the lowest intensity was in January, which amounted to 1845 individuals / m^2(fig.6).

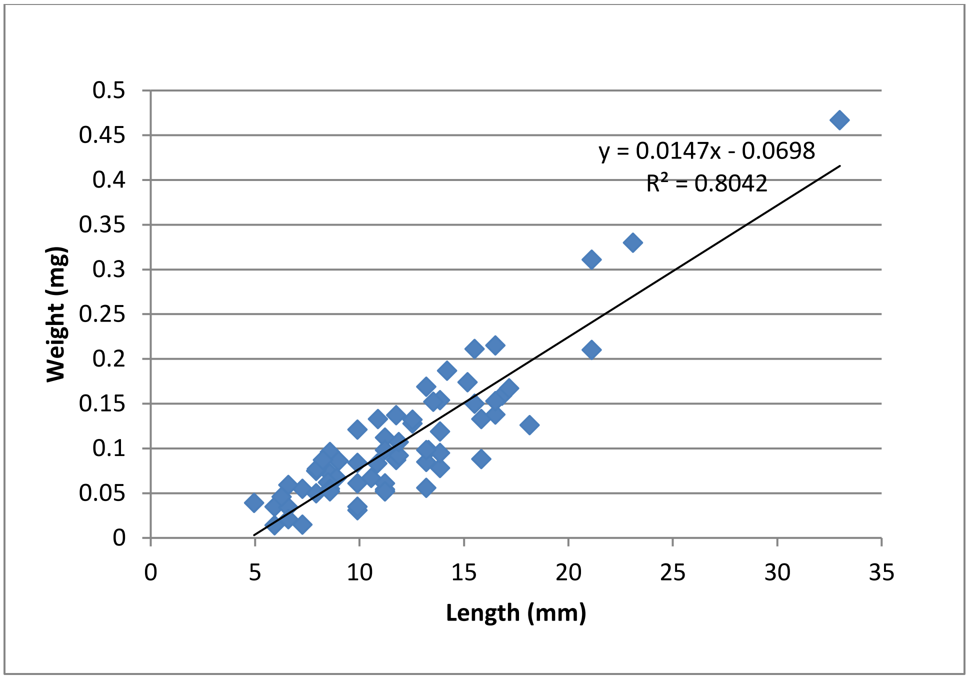

Figure (2). Length − weight relationship of *L. hoffmeisteri*.

Fig3: *L. hoffmeisteri* under magnification 2x and the true length of the worm was 15 mm.

The maximum recorded number of immature worms was 72/78.5 cm^2 during June while the lowest was in January at 7/78.5 cm^2. The maximum number of adults was during April and May, (13 individuals / 78.5 cm^2), and the lowest, was during March (2 individuals/78.5 cm^2). The worms carrying eggs appeared in six months only and the highest number recorded was eight individuals/78.5 cm^{2}during February, April and May (Fig.6).

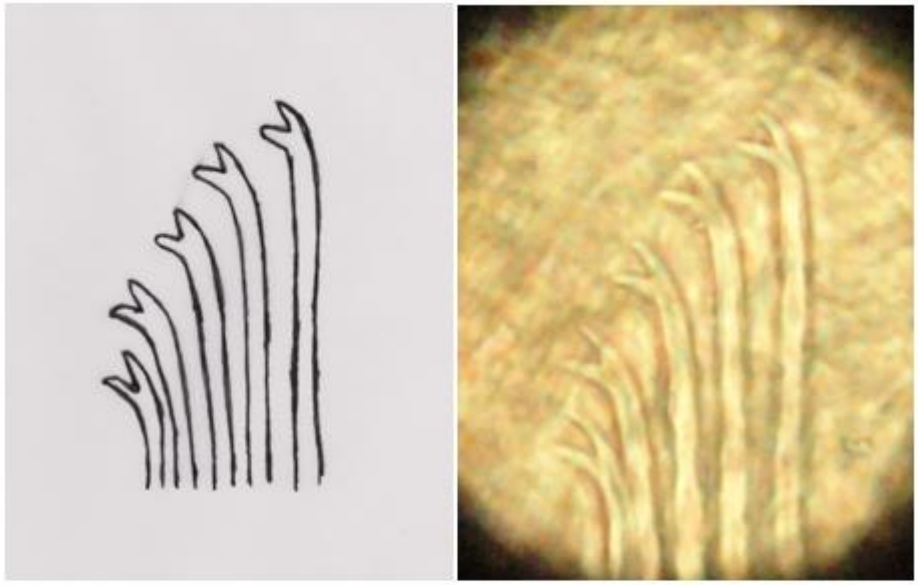

Fig.4: Bifid needle of *L. hoffmeisteri* (X = 40).

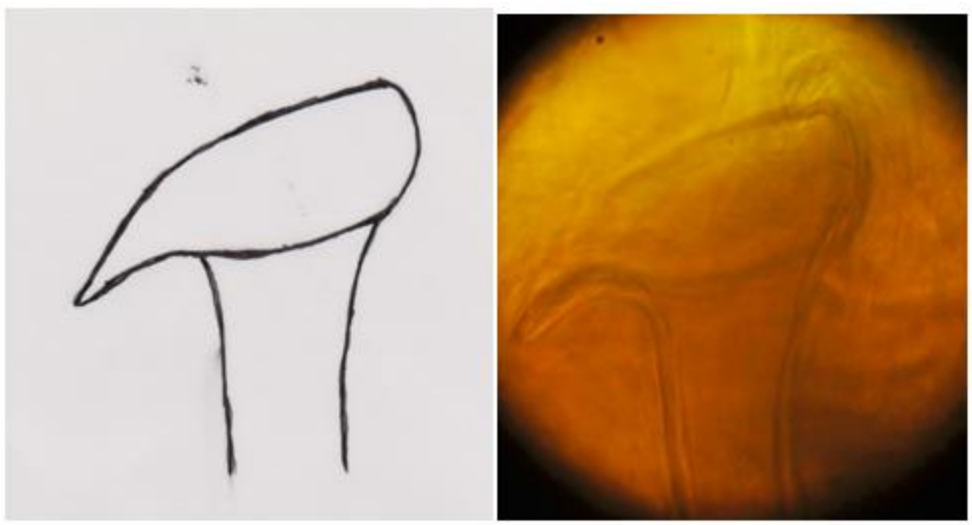

Fig.5: Penile sheath of *L. hoffmeisteri*.

Incubating and hatching of *L. hoffmeisteri*:

The weight of the chosen worms at sexual maturity for the hatching estimation ranged from 0.140 to 0.439 mg. The incubation period for the eggs to hatch lasted for 14-15 days at 25 ° C. The results showed that the number of worms, eggs and cocoons after 30 days at 15 ° C temperature reached 22, 29 and 6, respectively. While at the temperature of 20 ° C was 41, 37, 8, respectively, and temperature 25 ° C recorded 46 worms, 40 eggs and 9 cocoons, respectively. No hatching was recorded at incubation temperature of 10 ° C, but there was a remarkable growth within the cocoon (Fig10) which can be easily distinguished by comparing with the normal growth of the embryo at 25 ° C (Fig9). There was no significant difference (P>0.05) between the three temperatures (15, 20 and 25 °C) in their effect on the production of cocoons and eggs. There was no significant differences (P>0.05) also among the number of eggs in the cocoons at different temperatures. The average number of eggs in the cocoon was 4.4 eggs/ cocoon. The length of the worm during hatching was between 1.5-2 cm, the length of the cocoons was 2 mm (Fig7), and the maximum length was 26.48 mm in some adult worms.

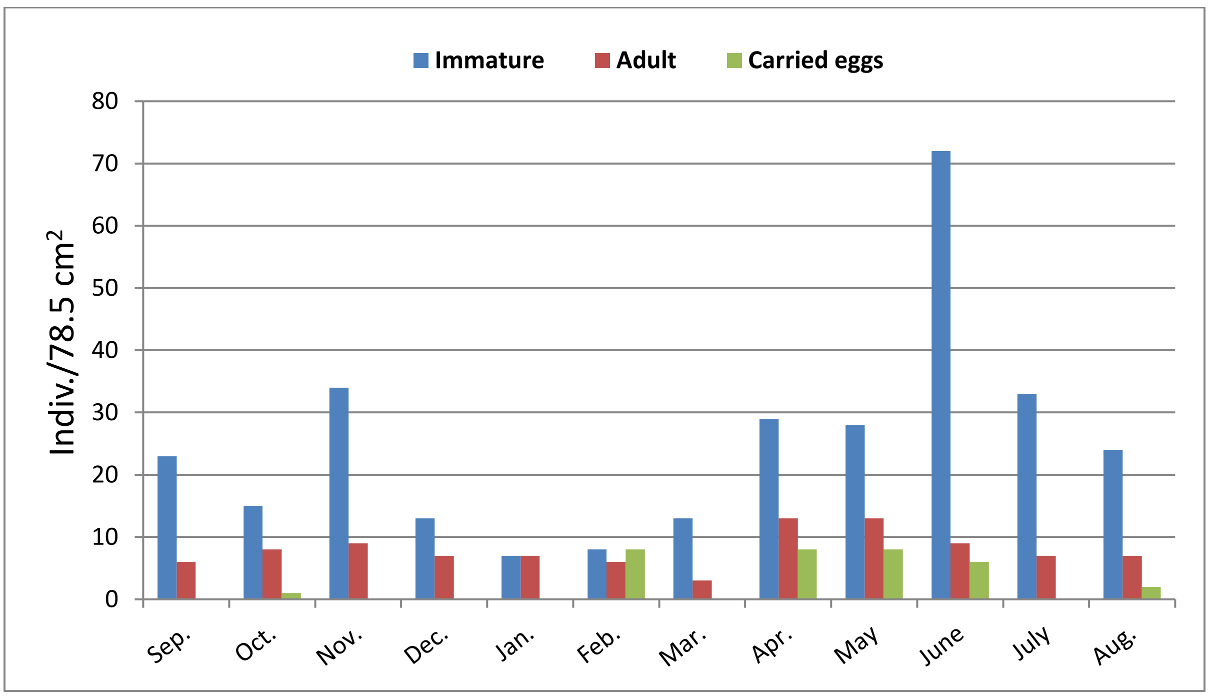

Fig6: Monthly variations of the maturing stages of *L. hoffmeisteri*.

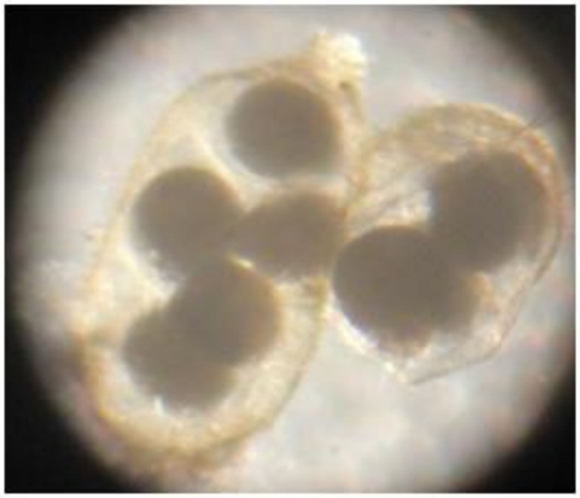

Fig 7: A model of the raised cocoons (2 mm scale).

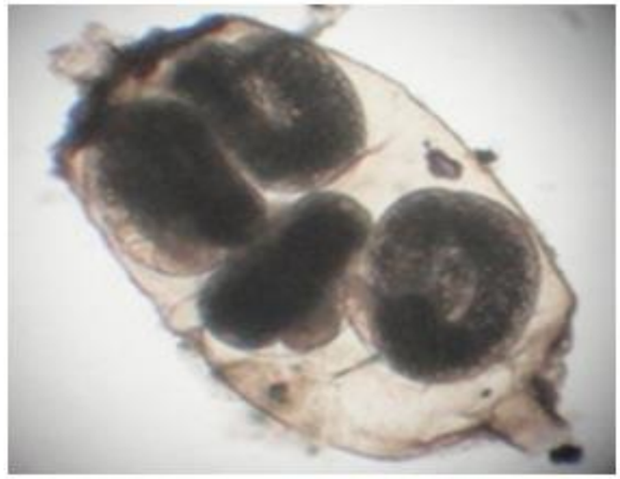

Fig8: Embryos at the end of the first week (2 mm scale).

Fig9: Normal growth of worms with hatching at 25 ° C.

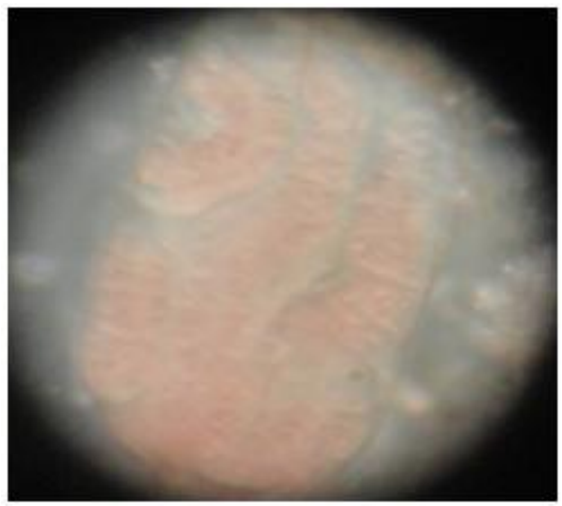

Fig10: The abnormal growth of worms inside the cocoon at 10 ° C.

In Figure 8, the shape of the embryos can be observed at the end of the first week of growth within the cocoon. At this time, its movement within the eggshell is limited and slightly. The study also found that the worms take 14-15 days to complete the growth of embryos and hatch.

Discussion

L. hoffmeisteri was recorded throughout the year which means that it tolerate a wide range of temperature. Hatching and incubation experiments also showed that the species could reproduce and grow within a range of temperature between 10-25 °C. The density of the species recorded in Shatt al-Arab is higher of that recorded by Nascimento and Alves (2009). The present study showed that the production of cocoons and eggs at 20 °C is higher than 15 °C. Average number of eggs per cocoon is compatible with that of Nascimento and Alves (2009). The reproductive activity of *L. hoffmeisteri* is compatible with that of *Streblospio* spp. (Levin and Greed, 1986) It was also shown by raising the worms under 10 °C, the embryos were growing inside the cocoon, but it was abnormal (Fig 10), as was hatched at 25 ° C. However, all embryos died after 9 weeks. The worms in the environment take special strategies to tolerate low temperatures and cannot be reared laboratory in such degrees.

The correlation coefficient of the length-weight relationship results are compatible with the high values estimated by Collins (1992) on Oligochaeta.

The current study showed that the density of *L. hoffmeisteri* ranged between 9-123 individuals/ 78.5 cm², which mean 1146-15669 individuals/m^2 during the study period. These results are compatible with the results of Jaweiret *et al*. (2012) in their study on the worms in the southern marshes of Iraq, where the species has recorded the highest proportion of the number of individuals. They reffered the cause of the high density of *L. hoffmeisteri* and *Tubifex tubifex* to the high proportion of organic substances in the region. The results of this study also agreed with the results of the Paoletti and Sambugar (1984) in the Po River in Italy who found that the species was predominant in addition to the species L. *udekemianus*. They explained that the reason for the abundance of these species is mainly due to the presence of a high proportion of organic substances in the environment and then the temperature and the amount of dissolved oxygen. However, the average number of individuals during the current study was higher than that recorded by Saad and Arlt (1977) in their studies on the meiofauna of Shatt Al-Arab. They recorded 2000 individuals/m^2 for all recorded species of oligochaete in the region. The level of organic matter in the region at that time of the study was 3.3% whereas in the current study and within one month recorded 6.97%.

Recorded lengths of hatchlings and the maximum length of adults in this study were less than that recorded in other parts of the world. Brinkhurst and Jamieson (1971) explained that the length of species is between 20-35 mm. The reason is due to predation by the fish or other organisms during the tide period, which causes the worm to regenerate the injured body parts, as well as the effect of anglers fishermen who use them as bait.

The instantaneous growth rate was recorded during the winter months; with negative values for species, this result is consistent with Johnson and Brinkhurst (1971). They found that the values of the instantaneous growth rate are decreasing during winter months and then increase during spring and summer ranging from 0.01-0.06 to oligochaete. These values are close to the current study values, 0.006 -0.1 of *L. hoffmeisteri.* This was due to the proliferative decline during cold months in addition to increasing death rate.

LÖhlein (1999) also found that the value of instantaneous growth rate of Naididae (family belongs to oligochaete) increases with increasing temperature. He was found that the worms began to die in the culture after 3-4 weeks, especially at high temperatures (above 25 ° C). and the instantaneous growth rate was between 0.02-0.19 in laboratory conditions, that is, approach to the values in the current study. The researcher attributed the difference in the values of growth rate in nature due to the difference in temperature and the amount of food available and predation efforts.

The average biomass of *L. hoffmeisteri* in Shatt Al-Arab was similar to that of Johnson and Brinkhurst (1971) in four regions of Canada with biomass of 1.17 g/m^2. Brinkhurst et al. (1972) showed that the average dry weight under the laboratory conditions of *L. hoffmeisteri* was higher than natural environment (0.4 mg and 0.2 mg, respectively). These results were compatible with the results of this study. The results of the current study showed that the productivity efficiency p / $\vec{B}$ was low, reaching 0.052

during the months of the study and this is due to high biomass rates.

The secondary productivity of *L. hoffmeisteri* was 0.1592 g / m² / year. While the productivity of Johnson and Brinkhurst (1971) for four groups of benthos (Crustaceans, Chironomids, Oligocheates, Sphaeiids) was 0.13 g /m^2/year as this value is lower than that obtained in the present study. This indicates that the environment in this region very suitable for secondary productivity under the conditions of organic matter, suitable temperature and low oxygen ratios. It is also possible to say that the species *L. hoffmeisteri* has a peak density at a specific time. High productivity and biomass of oligochaete could be considered a good indicator of the pollution of the aquatic environment due to its high accumulation of heavy elements in its soft tissues (Ciutat et al., 2005).

In Figure 8, the shape and movement of embryos within the cocoon at the end of the first week as well as and time laps of hatching are compatible to that of Nascimento and Alves (2009). Figure 9 shows the natural growth of the embryo inside the cocoon at 25 ° C compared to abnormal growth at 10 ° C (Fig10). The growth of embryos in the laboratory indicates that worms in the natural environment might change their hatching and growth strategies to resist inappropriate environmental conditions.

References

Brinkhurst, R. O. (1970). Distribution and abundance of Tubificid (Oligochaeta) species in Toronto Harbour, Lake Ontario. J. Fish. Res. Bd. Can., 27: 1961-1969.

Brinkhurst, R. O., Chua, K. E. and Kaushik, N. K. (1972). Inter specific interactions and selective feeding by Tubifcid Oligochaetes. Limnology and Oceanography, 17(1): 122-133.

Brinkhurst, R. O. and Jamieson, B. G. M. (1971). Aquatic Oligochaeta of The World. 1st edition. University of Toronto Press, Canda and United States, 860 pp.

Ciutat, A., Gerino, M., Mesmer-Dudons, N., Anschutz, P. and Boudou, A. (2005). Cadmium bioaccumulation in Tubificidae from the overlying water source and effects on bioturbation. Ecot. Envir. Saf., 60: 237-246.

Collins, P. T. (1992). Length-Biomass relationships for terrestrial Gastropoda and Oligochaeta. Amer. Midl. Nat., 128: 404-406.

Jaweir, H. J. , Sabtie, H. A. and Almukhtar E. A. (2012). Aquatic Oligochaetes of Iraq's Southern Marshes. J. Baghdad for Sci., 9(3): 472-480.

Jaweir, H. J. (2011). A new record of three tubificid species (Annelida : Oligochaeta) from Al-Hawiezah marsh, Iraq. Mesopot. J. Mar. Sci., 26(2): 114-121.

Johnson, M. G., Brinkhurst, R. O. (1971). Production of benthic macroinvertbrates of bay of Quinte and Lake Ontario. J. Fish. Res. Boa. Can., 28: 1699-1714.

Levin, L. A. and Greed, E. L. (1986) . Effect of temperature and food availability on reproductive responses of *Striblospio benedicti* (polychaeta : Spionidae) with planktotrophic and lecitotrophic development . Mar.Biol., 92:103-113.

Lindegaard, C. (1992). The role of zoobenthos in energy flow in deep, Oligotrophic Lake Thingvallavatn, Iceland. Hydrobiologia, 243/244: 185-195.

Liu, Y., Vermaat, J. E., Ruyter, E. D. and De Kruji, H. A. M. (2004). Modification and application of biomonitoring ISO BMWP method of macrofauna in river pollution evalution in China, Acta Scient. Natur. Univ. Sunya., 43(4): 102-105.

Lohlein, B. (1999). Assessment of secondary production of Naididae (Oligochaeta): an example from a north German lake. Hydrobiologia, 406: 191-198.

Nascimento, H. L. S. and Alves, R. G. (2009). The effect of temperature on the reproduction of *Limnodrillus hoffmeisteri* (Oligochaeta : Tubificidae). Zoologia, 26(1): 191-193.

Paoletti, A. and Sambugar, B. (1984). Oligochaeta of the middle Po River (Italy): principal component analysis of the benthic data. Hydrobiologia, 115: 145-152.

Risnoveanu, G. and Vadineanu, A. (2003). Long term functional changes within the Oligochaeta communities within the Danube River Delta, Romania. Hydrobilogia, 506-509: 399-405.

Saad, M. A. H. and Arlt, G. (1977). Studies on the bottom deposits and the Meiofauna of Shatt-Al-Arab and the Arabian Gulf. Cahiers De Biologie Marine, Tome XVIII: 71-84.

Smock, L. A., Gladden, J. E., Rickenberg, J. L., Smith, L. C. and Black, C. R. (1992). Lotic macroinvertebrate production in three dimensions: channel surface, hyporheic and floodplain environments. Ecology, 73: 876-886.

Thorp, J. H. and Covich, A. P. (1991). Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc., San Diego and California, U.S.A., 911 pp.

الإنتاجية الثانوية وبعض ملاحظات التكاثر للنوع ***Limnodrilus hoffmeisteri* (Claparede, 1862) (Oligochaete: Naididae: Tubificinae)** في شط العرب،البصرة،العراق

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الملخص

ينتمي النوع *Limnodrilus hoffmeisteri* الى شعبة الديدان الحلقية قليلة الاهلاب ،العائلة Tubificidae التي تقطن المياه العذبة وهي من الديدان القاعية الشائعة في شط العرب. جمعت العينات مرتين شهريا للفترة من ايلول 2012 الى اب 2013. جمعت العينات بأستعمال لباب بمساحة 78.5 سم^2. بلغ معدل وزن الافراد الحاملة للبيض بين 0.140-0.439 ملغم ،وبلغ اقصى طول للدودة 13.03ملم و0.577ملغم وزن جاف وبكتلة حية 2.944غم/م^2 . بلغ المحصول السنوي للكتلة 11.801غم/م^2 ،ومعدل نمو أني 0.107غم/م^2/سنة وكانت الانتاجية 0.1592غم/م^2/سنة. نمي النوع *L hoffmeisteri* مختبريا في ثلاث درجات حرارة وكانت الديدان المغذاة على الشوفان اعطت اعلى معدل نمو بينما المتغذية الخس اعطت اسرع وقت للبلوغ.

كلمات مفتاحية : احياء قاعية،انتاجية ثانوية ، ديدان بالغة ، وزن طري