INVASION OF ZEBRA MUSSEL *DREISSENA POLYMORPHA* PALLAS,1771) INTO THE COOLING SYSTEM WATER SUPPLY OF AL-MUSAYAB THERMAL POWER PLANT / IRAQ

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ABSTRACT

Zebra mussels *Dreissena polymorpha* are tiny bivalve mollusca , invade water supply of cooling system unit in Al-Musayab power plant, 60 km south-west Baghdad and grow to dense clusters. Its ability to rapidly colonize intake structures, such as pipes and screens causing reduction in water pumping capabilities .Some biological aspects of zebra mussel *Dreissena polymorpha* have been studied and some physical & chemical parameters were examined as alimenting factors for the species Samples collecting was done monthly from two sites within the water system , the first was the traveling band screen (TBS) and the other site was small canal collecting excess water passing from TBS .Biological studies revealed that the samples collected from the canal includes five size groups with average length of 5.7 ; 11.3 ; 16.7 ; 21.9 & 27.3 mm. In TBS , the individuals found all over the year with highest number of 135 individuals recorded in August . Individuals of a length of 11.3 & 16.7mm were the dominant.In general, from total number of 799 individuals collected from TBS, 388 individuals were of size of 11.3mm and 239 individual were of size 16.7mm while no large specimens of large size group of 27.3mm were recorded in TBS.To study the settlement rate of larvae, several concreat tiles of (25X25cm) were suspended at depths of 2,4& 6 m. in the sedimentation pond (12m depth). The number of juveniles were counted monthly . The result showed that there were two peaks of settlement , one in June and the other in September and October .Depth of 6m was the most suitable for settlement.The average length of settled juveniles ranged between 3.5-6.1mm. Water temperature in the site ranged between 11-32^{o} C , Dissolved oxygen was 4.8-8.3ml/L . The highest value of turbidity was 49NTU.Ca^{++} was 68-136mg/l and Mg^{++} was 34-72mg/l

INTRODUCTION:

Zebra mussels, *Dreissena polymorpha* (Pallas,1771) are tiny striped bivalve mollusks , they look like small clam with elongated D-shaped shell. They are usually marked with alternating dark & light bands, but the number and pattern of the bands or stripes is highly variable. Most zebra mussels are thumb nail size, but some grow up to two inches long.

Zebra mussels are dioecious. Female generally reproduce in their second year. Eggs are expelled by the female and fertilized externally during spring and summer, depending on water temperature. Optimal temperature for spawning is 14-16^{0}C. Over 40,000 eggs can be laid in a reproductive cycle and up to one million in spawning season. Spawning may last longer in water that are warm throughout the year (USGS,2002)

Following external fertilization and embryological development, there is a brief trochophore stage with the development of velum and secretion of a D-shaped larval shell, the larva become a D-shaped veliger ,which is the first recognizable planktonic larva. Later, the secretion of a second larval shell leads to the last obligate free swimming veliger stage known as the velichoncha .The last larval stage known as the pediveliger, however, can both swim using its velum or crowl using its fully functional foot. Pediveliger actively select substrates on which they settle by searching byssal threads and undergo metamorphosis to become a juvenile mussels (Ackerman, 1995)

Zebra mussels are filter feeders, they use their cilia to pull water into shell cavity. Each adult mussel is capable of filtering one liter of water per day or more, where they remove phytoplankton, zooplankton, algae and even their own veliger larvae (Snyder *et al* ,1997).Any undesirable particles is bound with mucus ,known as pseudofeces and ejected out the incurrent siphon, the particle-free water is then discarded out the excurrent siphon (Richerson ,2002)

Zebra mussel inhabit fresh water, usually at depths of 2-7 m .Even though they are fresh water animals, they can tolerate salinities up to 13.4 ppt., typical of estuarine system (USGS,2002). Fong *et al.* (1995) showed by experimental studies that the sudden increase in salinity produce an immediate decrease in the reproductive capacity , while acclimation to brackish water can occur and animal may be able to reproduce in brackish water below 7.0 ppt.

Zebra mussels are native to western Asia and were indigenous to the drainage basin of the Aral, Black and Caspian seas. By the late 18^{th} and early 19^{th} centuries it had spread to olmost all major drainages of Europe .In 1980s they were introduced in to North America by European cargo ship that discharged ballast water into the great lakes. By 1997 zebra mussels have spread to19 states in US. This invasive species was introduced to Euphrates river in Turkey and then distributes to Syrian and Iraqi sectors of the Euphrates river, especially after the construction of Kaban, Tabqa and Al-Qadisya dams.

The infestation of zebra mussels into many areas of the world has created a major economic problem due to their biofouling capabilities by colonizing water supply pipes of hydroelectric and nuclear power plants, public water supply plants and industrial facilities. They colonize pipes constricting flow, therefore reducing the intake in heat exchangers, condensers , fire fighting equipments and air conditioning and cooling system.

In Iraq zebra mussel invade water supply of many thermal power stations including Haditha and Al-musayab power plants . The aim of this study is to determine some biological aspects in order to evaluate the problem in Al-musayab power plant(60 km southwest Baghdad). Cooling system in this plant is absolutely open system where the water pass from the river to the sedimentation pond of 90 x 75x12 m dimensions. There is a concrete wall separate the river from the pond leaving bottom opening allowing water to pass and prevent large floating bodies . The water then passes through four channels, each one feed two tanks of 30m long and 10m width . The water passes from these tanks through a coarse screen of $10cm^2$ mesh to another tanks, then pass through a median metal screen called fine screen of $1cm^2$ mesh. After that the water pass through a third screen which is the traveling band screen (TBS) of $1mm^2$ mesh.TBS is a system of 54 cylindrical baskets of 40cm diameter and 150 cm long fixed in serial motion conveyers. TBS clean water from small suspended particles. The water pass through TBS to eight tanks of 6x5 x 23m from which water pulled to the cooling system by 8 motors The last tanks also supply the distillation unit in the plant with water.

There are four generators, each one is supplied with cooling system consist of two groups of pipes, each group consist of 7,000 pipes of 24mm diameter. Zebra mussels inter these pipes causing their constriction so that the water flow will be reduced leading to rising the temperature of generators and urge operators to switch them off for mechanical cleaning .

MATERIALS AND METHODS:

Zebra mussels were collected monthly from two sites within the power plant water supply, the first site is the traveling band screen and the other is a drainage canal collecting excess water from traveling band screen. Sampling extended for the period from November 2002 to October 2003.There were no data recorded for April 2003 due to military activities at that time. Animals were immediately transported to the laboratory and maintained in a glass aquarium (60 x 30 x 30cm) filled with water and kept in 20 ± 3^0C in an air-conditioning room.The water was supplied with fresh air at 7-8 h daily.

For each individual, length and height of the shell were measured.The weight of whole mussel with shell was measured using electrical balance and age was by counting the number of growth lines on the shell.

In order to determine the settlement rate of larvae during the study period, three groups of concrete tiles of (25X25cm) were suspended at a depth of 2, 2.5, 3, 4and 6m in the sedimentation pond (five tiles for each depth) . The tiles were pulled up once each month and the number of settled larvae was counted as well as their shell length were measured. Correlation coefficients were calculated to indicate the correlation between differing factors.

RESULTS & DISCUSSION:

Table (1) shows data of the physical and chemical parameters of water supply to the power plant cooling system. Water temperature was ranged between 11-32^0C, Dissolved oxygen shows its highest level of 8.3 mg/l in January and 4.8 mg/l in August The highest turbidity was recorded during April 46NTU .pH values ranged between7.3-8.0. Salinity, ranged between 0.40-0.78 ppt. The Ca^{++} and Mg^{++} concentration were ranged between 68.1-136.2 mg/land 7.2-72.9 mg/l , respectively

It was clear that all environmental conditions are suitable for survival and growth of zebra mussels. Temperature is one of the most important factors affecting distribution and abundance of zebra mussels. Karatayev *et al*. (1998) indicated that the maximum temperature tolerated by zebra mussels range between 32-35^0C , while in the present study the temperature reached 32^0C in August . This means that mussels can tolerate this high temperature.

Dissolved oxygen required by zebra mussels correlated with water temperature. Aldridge *et al.* (1995) shows a high rate of oxygen consumption at 20^0C, but zebra mussels can tolerate low dissolved oxygen concentration down to 4 mg/l (Matthews & McMahon,1999) .

The pH values of water were within the range suitable for the growth of zebra mussels. Karatayev *et al.* (1998) stated that the ideal pH for zebra mussel growth ranged between 7.4– 8.5,while Ludyanskiy *et al* .(1993) referred to a value ranged between 7.4 – 9 as a pH tolerant limit for zebra mussels.

Alexander *et al.* (1994) refers to the effects of turbidity on respiration , when the turbidity rise up to 80 NTU. , on the other hand zebra mussel itself help in reduction of turbidity since each individual is able to filter one liter of water per day (Snyder *et al*.1997)

Ca^{++} concentration is important for shell growth. The prefect Ca^{++} concentration for zebra mussel growth ranged between 25-125 mg/l (Karatayev *et al*.1998). Ludyanskiy *et al* (1993) refer to a value of 10 mg/l Ca^{++} for rapid growth of zebra mussels.

Samples collecting from drainage canal revealed that the population included five age groups: 0 ; I ; II ; III and IV years with average length of 5.11 ; 11.3 ; 16.7 ; 21.9 and 27.3 mm, respectively (Table 2). There are linear correlations between age & length and age & height with (r) values of 0.892, and 0.929 respectively. While (r) value was 0.972 between length& weight.

Table (1) : Physical & Chemical Parameters of water supplied to Al-Musayab Power Plant

Month	Temperature C^0	Dissolved oxygen Mg/l	pH	Turbidity NTU	Salinity ‰	Ca^{++} mg/l	Mg^{++} mg/l
November 2002	21	7.2	7.9	11	0.74	136.2	48.6
December	19	7.0	7.9	10	0.74	112.2	63.1
January 2003	11	8.3	7.7	12	0.77	120.0	72.9
February	11	8.1	8.0	10	0.78	92.1	63.1
March	14	7.8	7.8	05	0.65	68.1	36.4
April	No samples were collected during this month						
May	26	5.5	8.1	27	0.57	80.0	21.8
June	28	6.0	7.8	49	0.62	124.2	7.2
July	29	5.2	8.0	16	0.40	104.2	38.8
August	32	4.8	7.7	10	0.41	96.1	38.3
September	28	5.5	7.3	20	0.45	128.2	34.0
October	25	6.8	7.8	17	0.75	120.2	34.0

Table (2): Average length (mm); height (mm) and weight (mg) for each age group in the drainage canal sample

Age group	Average length	Range of length	Average height	Average weight
0	5.7	2-6	3.0	69
I	11.3	8-14	5.9	177
П	16.7	14-20	8.3	449
Ш	21.9	18-26	10.3	876
IV	27.3	26-30	12.2	1449

Fig (1) shows the values of the average length, height and weight of different age groups. Numbers of individuals of age group V were recorded in this site, i.e. the life span of species in this site is less than 5 years. Lewandowski *et al* (1997) and Chase & Bailey, (1999) recorded the same result in Majczwielki lake and St. Clair lake, respectively.

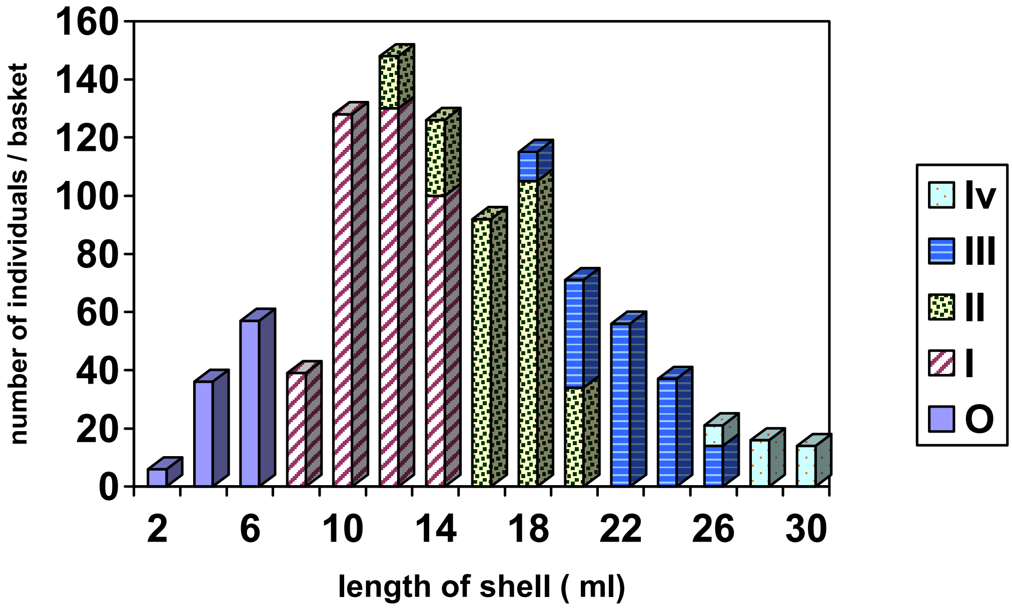

Fig (1):The lengths of the different age groups and their Frequency in the sample

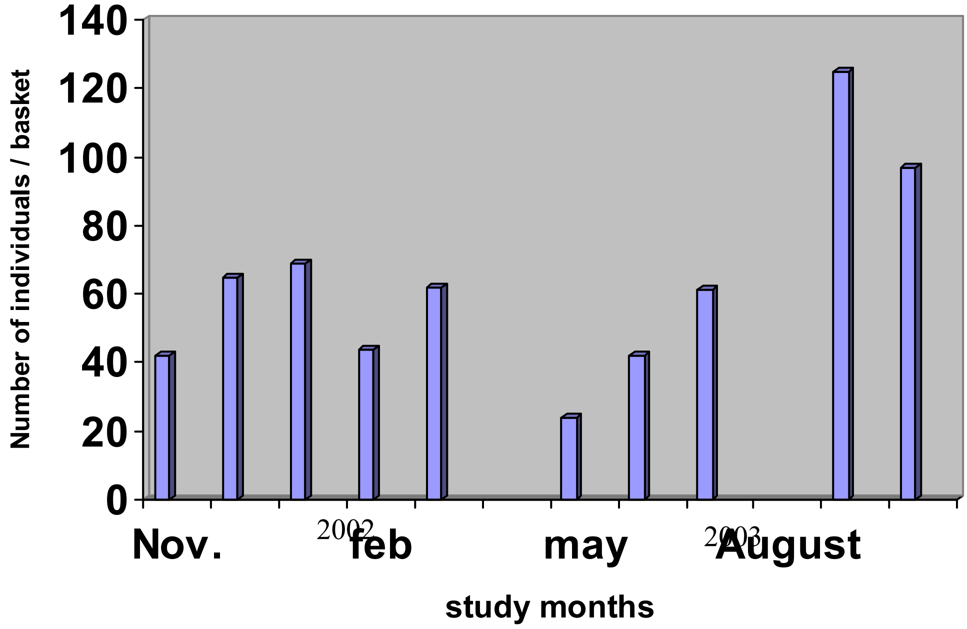

Fig (2):Number of zebra mussels collected from TBS during November 2002 to October 2003 .

Fig.(2) shows the number of individuals collecting from traveling band screen (TBS) during study period. The highest numbers were recorded in July and August of 137 & 176, respectively, while 60-110 individuals were found in other months. Age group I was the dominant throughout the study period (Fig 3) .There were no age group IV found in TBS.

Table (3) shows the number of settled larvae on suspended tiles at different depths. It was clear that there were two settlement periods, one starting from June ,so that add new larvae which reduce the average length to 2.8mm in August . The highest settlement rate noticed in November and December 2002 which reduced the average length to 1.5 and 2.3mm respectively.The settlement rate increased with depth, so that a depth of 6m was more suitable, for settlement. After fertilization , the larvae swim for some time before settled on different kinds of substrate even immersed aquatic plants and metamorphosis (Ram *et al.*1996). Garton& Haag (1993) also recorded a highest settlement rate occurred in a period from mid June to mid October in Lake Erie, US. Ackerman *et al*. (1994) stated that larvae need 8-90 day from fertilization to settlement phase , while Nichols (1996) indicated that the period from fertilization to settlement phase is correlated with water temperature, so that it becomes longer in cold season and may reach 240 days. Lewandowski (2001) indicated that the larvae settled when reached 300 micron in length, and Kabak (2001) noticed that the larvae prefer the dark places for settlement .

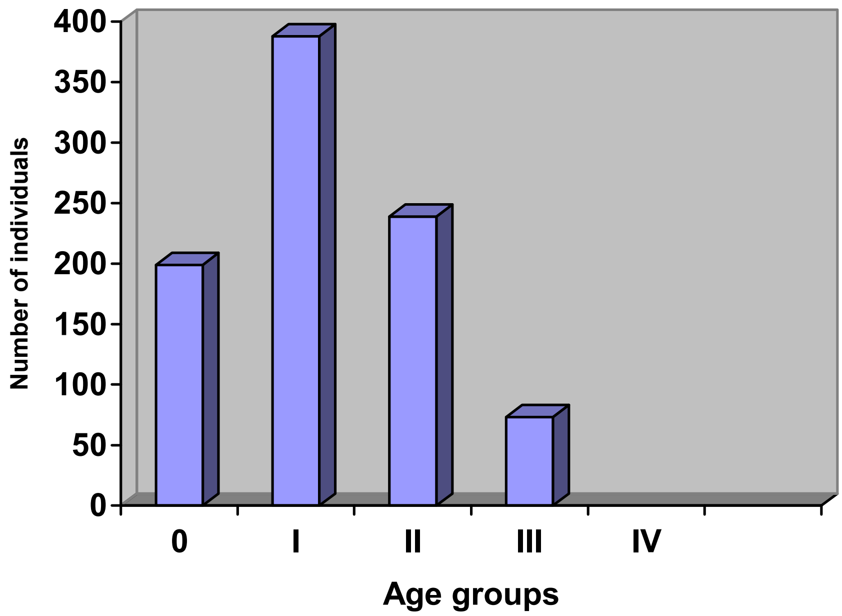

Fig (3): Number of different age groups of Zebra mussels in traveling band screen (TBS).

Table (3): Number of settled larvae on concrete tiles at different depths

Months	Depth (m)					Total number	Average length of settled larvae (mm)
	2	2.5	3	4	6		
January	-	-	-	2	3	5	3.5
February	2	2	2	13	11	30	4.5
March	14	13	4	17	14	62	4.2
May	18	14	14	22	22	90	4.6
June	22	23	26	28	30	129	5.1
July	16	18	18	19	20	91	4.1
August	12	11	8	14	15	60	2.8
September	10	3	3	10	11	37	4.9
October	15	5	5	16	12	53	6.1
November	110	175	103	254	216	858	1.5
December	150	210	250	400	360	1370	2.3
total	369	474	433	795	714	-	-

According to these results we conclude that the period prior to July or prior to November is the best time for control of zebra mussels in the cooling system water supply of Al-Mussayab power plant and it is better to control mussels in the sedimentation pond to prevent larvae or adult individuals to reach TBS or final tanks before entering the cooling system.

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اجتياح المحار المخطط *Dreissena polymorpha*(Pallas, 1771) في ماء تجهيز منظومة التبريد لمحطة كهرباء المسيب الحرارية / عراق

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الخلاصة

المحار المخطط *Dreissena polymorpha* هو نوع صغير من النواعم ذات المصراعين ، اجتاح ماء تجهيز منظومة التبريد التابعة لمحطة كهرباء المسيب الحرارية /60 كم جنوب غرب بغداد . لهذه الاحياء القدرة على التكاثر السريع مكونة تجمعات كبيرة تلتصق افرادها بعضها ببعض وتتجمع داخل انابيب الماء وعلى مشبكات الترشيح فتقلل من كفائتها في الترشيح اضافة الى انخفاض سرعة جريان الماء في الانابيب . درست بعض الجوانب الحياتية لهذا المحار ، اضافة لبعض العوامل الكيمياوية والفيزياوية المحدده لنموه . جمعت عينات النوع شهرياً من موقعين ضمن منظومة تجهيز الماء في هذه المحطة ، الموقع الاول ، الغربال الثالث او غربال الاحزمة المتحركة(TBS).اما الموقع الثاني فهو قناة لجمع الماء الزائد المتساقط من الغربال الثالث .اشارت نتائج الدراسة الحياتية الى ان العينات التي تم جمعها من القناة تضم خمس فئات حجمية بمعدل اطوال 5.7 و 11.3 و 16.7 و 21.9 و 27.3 ملم اما في الغربال الثالث فقد لوحظ تواجد الافراد على مدار السنة وسجل اعلى عدد للافراد 135 فرد خلال شهر اب ، وكانت الافراد من فئة 11.3 و 16.7 ملم هي السائدة ، وعموماً فان من مجموع 799 فرد تم جمعها من الغربال الثالث ، 388 فرد من الفئة الحجمية 11.3 ملم و239 فرد من الفئة الحجمية 16.7 ملم ، بينما لم تسجل الفئة الحجمية الكبيرة (27.3 ملم) أي تواجد لها في الغربال الثالث . ولغرض دراسة كفاءة رسوخ اليرقات علقت عدد من البلاطات الكونكريتية (25x 25) ملم على اعماق 2 و4 و 6 متر داخل احواض الترسيب (عمق 12 متر) وسجل عدد اليرقات المترسخة على البلاطات شهرياً .اشارت النتائج الى وجود قمتين للرسوخ ، واحدة في شهر حزيران والثانية في شهر ايلول وتشرين اول كما سجلت البلاطات في العمق 6 متر اعلى معدل لرسوخ اليرقات . تراوح معدل طول اليافعات الراسخة على البلطات خلال فترة الدراسة بين 3.5 – 6.1 ملم .تراوحت درجة حرارة الماء خلال الدراسة بين 11-32 ^{0} م وقيم الاوكسجين بين 4.8 – 8 مل / لتر . وسجل اعلى قيمة للعكورة 49 وحدة عكورة . اما قيم تركيز الكلسيوم فتراوحت بين 86 – 136 ملغم /لتر ، والمغنسيوم 34 – 72 ملغم / لتر .