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Effect of temperature on haemodynamics and movements of thoracic appendages of fairy shrimp *Streptocephalus dichotomous* [Branchiopoda: Anostraca]

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Abstract
Effect of temperature on haemodynamics and movements of thoracic appendages of fairy shrimp *Streptocephalus dichotomous* were quantified in a series of experiments. It has been observed with help of Joseph's Rotary Video Microscope (JRVM) that activity of thoracic appendages was related to temperature variations. For this experiment, a 500 ml storage water tank was connected to the mini culture chamber, provided with a valve meant for regulating the flow of water and placed on the stage of microscope. The appendages were functioning as respiratory structures and their movement is required for active respiration to maintain the metabolic rate. The movement of the blood in *S. dichotomous* is directly proportion to the contractions of heart which inturn is related to the temperature variations. The rate of heart contractions increases with high temperature and reduces in low temperature.

Keywords: *streptocephalus dichotomous*, haemodynamics and thoracic appendages

Introduction
The Branchiopods are a primitive and diverse class of the Crustacea characterized by flattened and foliaceous thoracic appendages (thoracopods); these structures have respiratory (as well as other) function and hence the name branchiopoda [1]. It is a reasonably small taxon of primarily freshwater crustaceans with numerous primeval members like fairy shrimps, tadpole shrimps and encompasses highly modified associates of Cladocerans [2]. Except cladocera the remaining are known as large branchiopod or non cladoceran branchiopods. Presently 40 species of large branchiopods under 14 genera, 11 families and 4 orders are known to occur in India. The non-cladocerans (Anostraca=fairy shrimps, Notostraca=tadpole shrimps, Laevicaudata=smooth clam shrimps) are generally named as ‘large branchiopods’, despite the group being clearly paraphyletic, evertheless, they share a number of common characteristics like serially similar phyllopodous trunk limbs, their preference for temporary wetlands or salt lakes [2]. In India many of the major groups of non-cladoceran or large branchiopods are well represented in various temporary and semi-permanent water bodies, occasionally in some permanent water bodies. The anostracans, inhabiting temporary rain pools and permanent saltwater worldwide, are branchiopods lacking a carapace and with 19-27 postcephalic segments of which 9-19 carry a pair of similar, foliaceous limbs [3]. Most of them are about 10-30 mm long (extreme range 5-150 mm), and consist of a long cylindrical body divided into a head, a thorax with many pairs of foliaceous limbs, the genitalia, and an abdomen and interestingly the fairy shrimps swim upside down [4].
Temperature is one of the most important factors controlling the physiological process of all organisms. It acts as the cellular level by increasing or decreasing the catylytic activity of metabolic and digestive enzymes. It also maintains a direct relationship with growth rate and other whole body functions involved in the energy metabolism (respiration) and other activities including swimming in invertebrates [5, 6] and specific dynamic action in crustaceans [7]. The mechanisms of swimming performance in the aquatic micro crustaceans such as copepods [8, 9] Isopods [10] branchiopods [11] Cladocerans [12]. The movement of appendages and the swimming speed depend on abiotic conditions, individual age and size of the organisms [13]. The change of temperature effects the swimming performance, fishes either at temperature to which they are acclimated [14, 15] or at temperature to which they are acutely introduced [16]. Both acute and acclimatory increases in temperature have been shown to improve swimming performance of enhancing biochemical reaction rate [17]. Skeletal muscle centractility [18], cardiac performance [19] and hydrodynamics [20] of the aquatic organisms.
The haemodynamics in crustaceans mainly controlled by the rate of heat beat. The changing pattern of flow in higher groups of animals takes place by localised or general vasoconstriction and vasodilation of the blood vessel. But in Arthropods it appears not having such control system for the regulation of blood flows. In crustaceans, the blood flow and blood pressure are regulated by exclusively by the performance of the heart [21]. The critacal parameters such as rate of heart beat, stroke volume, force and velocity of myocardial contractions are important for regulation of blood to the different organs of the body. Taken into account of fairy shrimp *S. dichotomus*, the haemodynamics and movements of thoracic appendages for the present study.

Material and Methods
One hundred specimens of fairy shrimp *S. dichatomus* along

with their habitat water collected from Acharya Nagarjuna University fish farm (ground nurseries) at Nagarjuna Nagar, Guntur District, Andhra Pradesh and carefully brought to laboratory with oxygenated bags. The active and healthy specimens were taken with the help of a droper and introduced carefully into miniculture chamber. It was placed on the stage of Joseph's Rotary Video Microscope. *Mini Culture Chamber:* It is a thin glass chamber having measurements of 4cm x 0.5cm x 2cm. The bottom of chamber have a opening which connected to thin plastic transparent flexible tube provided with mini plastic valve to regulated the water flow.

Reserve Tank: It has a bottle shaped plastic reserve tank of 500ml capacity. The broder end of the reserve tank provided with 3mm square opening transparent flexible tube. The tube is provided with plastic minivalve to regulate water flow from reserve tank. The different higher grades of temperature of habitat water was maintained in reserve tank with the help of a mini electric water heater, which was connected to a voltage regulator. Joseph's Rotary vedeo microscope having facility to see magnified image of the speciman at an angle ranging from 0 – 360° horizontal and 360° vertical with different angle of sagital plaine without disturbance of experimental specimen on microscopec stage. This type of microscope facilitate magnified view from any direction of the specimen in a moniter.

The temperature is one of the important ecological parameter which controlling all metabolic and other activities of the organisms. Different grades of temperature of the habitat water has maintained and carefully transferred from storage tank to the minicu-lture chamber upto required level, before introducing experimental specimen. Different angles of the position and function of the heart and flow of blood in the different regions of the body and number of strokes of thoracic appendages were recorded by using three video microscopes and digital video camera.

Results and Discussion

The external features of crustacean heart ingeneral varies from tubular, oval or conical in shape situated in the posterior region of middorsal cephalo lothorax. In *S. dicotomus* the conicail / oval in shape, where broader end is towards the posterior end of middonsal cephalothoracic region. It is suspended by series of ligments in the blood known as pericardium. It is observed when it is in a disturbed state of condition with constant rhythum in relation to temperature. Heart beat of *S. dichotomus* in relation to different grades of temperature was recorded (Fig-1).

9°C : 1 stroke (beat) / sec or 60 strokes/minute. Animal was active.

18°C: At this temperature the heart beat was 2 strokes /second. Animal was active and normal.

27°C: 4 strokes / second. The animal exhibited normal activity.

36°C: 6 Strokes / second.

45°C: 8 strokes / second. The maximum activity of the animal was observed.

54°C: In this temperature heart beat was recorded 12 strokes/second.

The animal is in distress state and loosing its balance.

The haemodynamics in crustacean body as in other groups of animals mainly controlled by the rate of heart beat. The changing pattern of flow in higher group of animals trakes place by localised or general vasoconstriction and vasodilation of blood vessel. But in arthropod it appears not having such control system for the regulation of blood flow. In crustaceans the blood flow and blood pressure, regulated exclusively by the performance of heart [21]. The critical parameters such as rate of heart beat, stroke volume, force and velocity of myocardial contractions are important for regulation of blood to the different organs of the body. The rate of heart beat may vary on the basis of different parameters. A limited work has been done, due to non-availability of proper equipment, especially to study the adults and larval forms of crustaceans. Prasada Rao *et al.* [22] studied the limpet *Cellana radita* with the help of indigenous LDR (Light Development Resistor) technique. Temperature play very important role for regulating the rate of heart beat among the crustaceans. on the basis of experimental results *S. dichotomous* exhibit that there is a relationship between temperature and rate of heart beat. When temperature is lowered there is clear reduction of heart beat from 27°C, 4 (strokes) beats/second to one beat/second at 9°C.

In the highest grade of temperature the heart beat increased. At the temperature 54°C the heart beat was 720 beats/minute [12 strokes/second]. The animal is in destress state and loosing its balance. The present results shows that heart beat of *S.dichotomous* similar with the work of Robertson [23]. He reported that there is an increased rate of heart beat in relation to raising temperature. Seiwell [24] also reported that with the raising of the temperature the rate of heart beat also increased in cladoceran. Many species can be cultured on a diet composd of algae. Belman [25] discussed in general rate of heart beat among crustaceans.

The fairy shrimp *S.dichotomous* swim gracefully on their backs and the appendages are always faced towards the source of light. Mature specimens frequently rest on their back on the bottom sediments. Fairy shrimps are filter feeders, collecting algae, detritus and bacteria on the filter screen on their trunk limbs and pushing a food bolus along the ventral food groove or of micronized inert particle [26, 27]. However, that does not mean that these species are pure herbivores. Infact it has been observed that fairy shrimp stage of grow to an adult body lenght 1 - 3 cm readily catch and eat small animals, like nematodes, rotifers and larvae of copepods and cladocerons [28]. These animals fed their own naupli on top of an algal diet have 30% increase in reproductive output, and an increase in somatic growth rate [29].

Primitive crustacean heart is tubular and the heart wall consists of a single layer of myocardial cells and no nerve cells were found in the heart. Heart beat rhythmical frequency is of 120 to 240 beats/minute and each beat is associated with a slow membrane potential change in the heart muscle [30]. The heart beat is regulated by the central nervous system through accelerator and inhibitor nerve fibers and one can generally assumes that these cardioregulator nerves act on the heart ganglion rather than on the heart muscle [31]. The energetic acts of this acceleration can be substancial relative to locomotion as a constant velocity, even for small crustaceans [32]. Hunt *et al.* [33] reported Kinematic studies of cypridoidean ostracodi Cypridopsis vidua. They stated that the swimming in this species is drag based, with thrust provided by antennulae and antenna. They further stated that ostrocode swimming smoothly continuous, without rapid acceleration and decleration characteristic of most small aquatic arthopods. In the present study *S. dichotomous* was also never stopped completely but swims smoothly and continuously. The effect of electrical stimulation of cardio acclerator and cordio inhibitor nerves on the mechanically reported to heart beat isopod [34]. The temperature has a strong impact on craw fish metabolism was studied by Cameron and Mangum [35] and survival rate was observed by Mason [36]. Behroz *et al.* [37] observed combined effects of temperature and salinity on hatching performance of three anostracan species, *Phallocryptus spinosa, Branchinecta orientalis and Streptocephalus torvicornis* from East and West Azerbaijan, Iran. Temperature was influences the ecological characters of aquatic organisms especially on locomotion, behavior, reproduction. The appendages were functioning as respiratory structures and their movement is required for active respiration to maintain the metabolic rate. The movement of the blood in *S. dichotomous* is directly proportion to the contractions of heart which is related temperature variations.

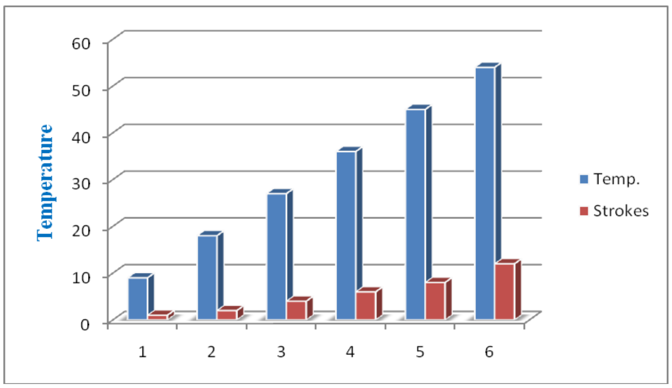

Fig 1: *Heart beat of the S. dichotomus with different temperature.*

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