Locomotion and Resting activities of Water Strider *Cylindrostethus costalis costalis* Schmidt, 1915 (Gerridae) in relation to surface tension in selected ponds from Sozhampettai, Mayiladuthurai District, Tamilnadu, India

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Abstract

Water striders or pond skaters are fascinating creatures which seem to glide over the surface of the water. The pressure of a leg produces a trough shaped depression (meniscus) on the water surface film, and the surface tension of the water easily supports the weight of the insect. The present investigation was carried out on the locomotion and resting times of water strider *Cylindrostethus costalis costalis* in two different ponds ie. culture and natural ponds. Moreover, the locomotion and resting time might be influenced by various physical factors of water. The results showed that, in culture pond water strider was spend more average time in evening hours (12.73 minutes/20 minutes) and less in morning hours (11.00 minutes/20 minutes) for locomotion. In natural pond, average locomotion time was high in morning hours (15.15 minutes/20 minutes) and less in evening hours (13.58 minutes/20 minutes). In culture pond, water strider was spend more average time in morning hours (9.05 minutes/20 minutes) and less in evening hours (7.9 minutes/20 minutes) for resting. In natural pond, average resting time was high in morning hours (4.4 minutes/20 minutes) and less in evening hours (2.7 minutes/20 minutes). The independent factors not much influence the water strider locomotion and resting activities. It concluded that, the study was short term, temporal and less sample size were did not showed much relationship among the dependent and independent factors. It also needs to research the relationships of the independent and dependent factors in long term, spatial study.

Key words:water strider, surface tension, dissolved oxygen, viscosity, temperature

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INTRODUCTION

Walking on a water surface is always a beautiful and fantastic dream for human beings, whereas for water striders, it is a rather familiar scene. The water strider is a type of common insect that lives in ponds and lakes. It has a remarkable ability to stand, walk, and even leap on a water surface smoothly (Dickinson, 2003; Hu *et al.*,, 2007; Gao and Feng, 2011). Original studies about the physical mechanism have exposed that the force to support the water strider is mainly composed of three parts: the optimism force, the curvature force, and the buckle force (Hu *et al.*,, 2003). A number of organisms make use of this unusual environment, some just passing through the way an aquatic mite does when quitting its underwater existence (Meyer, 1985) and others, like water boatmen (Hemiptera: Corixidae: Hinton, 1976), refreshing the oxygen they utilize in plastron respiration (Flynn and Bush, 2008). For some, though, like water striders and fishing spiders, the boundary is their primary (if not necessarily their obligate) physical substrate, supporting communication, predation, and locomotion (Wilcox 1979; Foelix 2011).

The locomotion of the water strider is initiated from the momentum of the swirling vortices beneath the water surface, like an oar (Hu and Bush, 2005; Bush and Hu, 2006). Also, chemical scientists have further studied the water strider and found that the excellent water-walking ability is derived from the better water repellency of the strider legs, which possessed thousands of tiny setae with fine nanogroove structures (Gao and Jiang, 2004). These setae and nanogrooves can trap abundant air bubbles under the water and provide a strong supporting force for the water strider to stand/run on a water surface (Feng *et al.*,, 2007; Watson *et al.*,, 2010; Ji *et al.*,, 2012).

Water striders skate easily on the surface of water mainly because their low body mass and superhydrophobic legs allow them to be carried on their tarsi (the proximal segment of an arthropod's foot) by surface tension alone (Hu *et al.*,, 2003). They

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are able to generate adequate vertical propulsion to disengage or jump from the water surface—actions that require high momentum with a high vertical take-off velocity. Whereas substantial advances have been made in the field of bio-locomotion, the hydrodynamics underlying the surface locomotion of semi-aquatic insects' remains poorly understood. Textured surfaces are known to play a significant dynamical role for a number of swimmers and fliers (Bushnell and Moore, 1991); however, no creature depends more critically on its surface structure than do water-walking arthropods. Their surface irregularity is critical in maintaining water-repellency, generating thrust as they strike the water surface, reducing drag as they glide across the surface and making buoyancy and permitting respiration when they are submerged. The hydrophobicity of solid surfaces plays a noteworthy role in various biological processes and industrial applications. Investigating this unique water-proof performance and mimicking the water strider leg have attracted much consideration (Wu and Shi, 2006; Larmour *et al.*,, 2007; Wu *et al.*,, 2008; Yao *et al.*,, 2010; Liu *et al.*,, 2012). It can be helpful to develop some water standing/ walking microdevices, which will have potential functions in exploring and monitoring activities on the water surface (Sun *et al.*,, 2005; Wang *et al.*,, 2010; Yao *et al.*,, 2011; Liu and Jiang, 2011; Samaha *et al.*,, 2012; Lepore *et al.*,, 2013).

A number of water-walking arthropods, including water striders, spiders and Collembola, can leap off the free surface using a variety of techniques (Suter and Gruenwald 2000; Suter 2003). The strider can row so vigorously that it rockets into the air and lands more than 10 body lengths away. After a very long literature review, the present study was initiated to record the locomotion and resting activities of water strider *Cylindrostethus costalis costalis* against selected physical factors in two different ponds (natural and culture ponds) from Sozhampettai, Mayiladuthurai, Tamilnadu, India.

Materials and Methods

The study was carried out from December 2019 to March 2020 in two different ponds (Culture and Natural ponds) in Sozhampettai village, Mayiladuthurai Dist. Direct survey and observation were made in two different ponds to locate the study species and record the skating time and resting time in morning (07.00 to 08.00) and evening (17.00 to 18.00) hours by visual encounter methods (VES). The hour was divided into four periods which will include 5 minutes of observation and ten of minutes break.

Physical factors analysis

During the survey, the water samples were collected and analysed in laboratory immediately. The levels of Dissolved oxygen (Winkler, 1888), Surface tension (Drop weight method- Gans and Harkins, 1930),

Table 1. Time spent (minutes) by water striders in different activities and physic-chemical variables of the ponds during morning and evening hours (values are Mean ±1S; N=18)

Variables	Culture pond		Natural pond	
	Morning	Evening	Morning	Evening
Locomotion (minutes)	11±5.8	12.73±8.3	15.15±6.5	13.58±5.9
Rest (minutes)	9.05±2.1	7.9±1.1	4.4±1.8	2.7±1.3
Surface tension ($dyn.cm^{-1}$)	72.42±0.32	69.24±0.24	69.23±0.07	68.19±0.06
Oxygen (mg/L)	7.8±0.1	7.1±0.1	7.3±0.2	6.7±0.02
Viscosity (poise)	1.002±0.001	0.916±0.008	1.011±0.004	0.877±0.009
Temperature (Celsius)	20.5±0.2	24.2±0.2	21.7±1.2	24.7±1.3

Table 2. Correlations between the time spent on locomotion and resting by the water striders and the physic-chemical variables of the ponds (n=18) (" - indicates significant positive correlation P<0)

Physico-chemical variables of the ponds	Locomotion Activity				Resting Activity			
	Culture pond		Natural pond		Culture pond		Natural pond	
	M	E	M	E	M	E	M	E
Surface tension	-	?	-	?	?	?	-	-
Dissolved Oxygen	-	-	-	-	-	-	-	-
Viscosity	?	-	?	-	-	?	-	-
Temperature	-	?	-	-	?	-	-	?

Viscosity (Capillary flow method) and temperature (Mercury thermometer) were assessed in both ponds.

Statistical Analysis

The relationships between locomotion and determining factors (Dissolved oxygen, Surface tension, Viscosity and temperature) were arrived at by Correlation analyses. Correlations between resting time and determining factors was also assessed. Statistical analysis were done using SPSS 16.

RESULTS

The average time spent by the water strider in locomotion was higher in the evening hours when compared to that of morning hours in the culture pond, while in the natural pond it was otherwise with the water strider spending more time in locomotion in the morning hours (Table 1). The average time spent in resting by the water strider was also more in the morning hours in the culture pond and in the natural pond as well (Table 1). There were significant correlations between the activities (locomotion and resting) of the water striders and surface tension, viscosity and temperature in both the ponds (Table 2).

DISCUSSION

The present study focused on the locomotion and resting activity of water strider in relation to the some physic-chemical factors of water in two different kinds of ponds. The physical factors assessed were surface tension, dissolved oxygen, viscosity and temperature recorded during period along with the locomotion and resting time of water strider. It shows that, greater variations among the morning and evening hours of time spend for locomotion in culture pond as well as natural pond. In culture pond, water strider was spending more average time during the evening hours and less in morning hours for locomotion. In natural pond, average locomotion time was high in morning hours and less in evening hours.

Commonly the culture ponds were fed with many organic fertilizers and food to get improved growth of cultivable organism. Moreover, the farmer will gain more income from this culture trails. Due to the more organic fertilizers, the culture pond might have been more diversity of prey items in surface layer itself ie. phytoplankton, zooplankton and small aquatic insects and their larvae. Hence, this might be the reason for decreased activity of the locomotion in culture pond. Natural ponds have only natural prey resources (as there is no addition of organic feed or fertilizers) to water strider. This might be the reason for increased locomotion activity of locomotion in natural ponds.

In this present study, the surface tension had influenced though not much in the locomotion and resting time of water strider. It may be due the sample size (n=18), short term and the temporal study. Sun *et al.,* (2018) have revealed and calculated the adhesion force of setae present in leg of water strider with the help of surface tension of the medium. Since the major source of the insect's ability to float is due to the surface tension force, (Liu *et al.,* 2005) that is associated with the deformation of a liquid surface, the liquid surface morphology near a water strider's legs is increasingly becoming an intensely researched area. Recently, Liu *et al.,* (2012) have found, the water displaced by the dimple is equal to the lift force by the surface tension, gravity, mass of the water strider and density of water. This would in turn support the observation of Hu *et al.,* (2003) that the bigger the species is, the longer the legs are, which avoids breaking the surface tension layer; however, the biggest animals would be close to the size limit for water walkers. Bush and Hu (2006) suggested that curvature forces (i.e. surface tension) would also be important at least during the rowing gate.

Apart from the surface tension, the present study also evaluated the influences of dissolved oxygen, viscosity and temperature on the locomotion and resting activity of water strider. While oxygen demands occur in water, the water strider continually gets locomotion to recover from stress. This phenomenon is common for the all aquatic organism which live in surface layer water. Many studies revealed a relationship between the dissolved oxygen and activities of organism at the surface of water. Arijit *et al.,* (2012) found a negative correlation between the dissolved oxygen and selected insect distribution in fresh water ecosystem. A large variation in dissolved oxygen (DO) concentration of water is expected to limit activities of semiaquatic insects (Hirayama and Kasuya, 2008). The above literatures are strongly in accordance with our results, (i.e) decreased oxygen will result in increased locomotion and decreased resting activity. Earlier study on the prevalence of water striders in varying environments, showed that water striders most prefer waters around 25 °C (77 °F) and water temperature lower than 22 °C (72 °F) is unfavorable (Anderson *et al.,* 2004). This is likely due to the fact that development rates of young are temperature dependent (Anderson, 1997). In accordance with this, our study also revealed that temperature to influence variation of locomotion and resting activities of water strider.

Viscosity did not influence much the locomotion and resting activities of water strider. But, earlier studies mentioned that the vertical center no longer moves until the vortex decays and disappears, due to the fluid viscosity dissipation after the strider leaves the water surface (Akira, 2012).

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