

# Behavioral activities of the giant water bug *Lethocerus indicus* (Lepeletier et Serville, 1775)

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## ABSTRACT

The study on behavioral activities of the giant water bug *Lethocerus indicus* was conducted at the Centre for Biodiversity Resources Education and Development (CEBRED), Hanoi National University of Education (HNUe). Twelve types of behavioral activity (BA) were identified and described: BA1: Horizontally floating, BA2: Diagonally floating, BA3: Swimming on the water surface, BA4: Swimming under the water surface, BA5: Respiration by extension and retraction pair of siphon, BA6: Capturing and eating prey, BA7: Vibrating legs, BA8: Opening and flapping wings, BA9: Clinging to each other, BA10: Crawling out of water, BA11: Death-feigning, and BA12: Attacking and cannibalizing each other. These 12 behavioral activities observed descended in the following order: (1) BA2 (17,24%) > (2) BA4 (16,94%) > (3) BA3 (15,75%) > (4) BA5 (14,86%) > (5) BA1 (12,18%) > (6) BA6 (11,14%) > (7) BA9 (6,99%) > (8) BA7 (2,97%) > (9) BA8 (1,34%) > (10) BA12 (0,30%) > (11) BA10 (0,15%) > (12) BA11 (0,15%). These behavioral activities can be grouped into 3 groups based on their scientific basis: Genetically (92%) > Ecologically (4.5%) > Physiologically (3.5%). This research on the behavioral activities of the giant water bug *Lethocerus indicus* can be considered an important scientific basis to be implemented in the raising and sustainable conservation of the species listed in The Vietnam Red Data Book since 1992.

**Key words:** Behavior, giant water bug *Lethocerus indicus* (Hemiptera: Belostomatidae), Red Data Book, raising and sustainable conservation

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## INTRODUCTION

Giant water bug is a part of subfamily Lethocerinae, family Belostomatidae, order Hemiptera. They live in aquatic habitats with slow water flow (a bayou), such as lakes, ponds, marshes, river edges and streams. They regularly have a length of approximately 8-9 cm, with the largest being up to 12 cm long<sup>1-4</sup>. In Vietnam, giant water bugs began to be researched, and their behavioral activities were briefly described approximately 100 years ago by Nguyen Cong Tieu<sup>5</sup>. Vu Quang Manh has continued his in-depth study of giant water bug morphology, habitats, courtship behavior, etc.<sup>6-8</sup>. There has yet to be full and extensive research on the behaviors of giant water bugs in Vietnam. In 1970, Guthrie and Iverson published the first research on general observations of captive giant water bug behaviors<sup>9</sup>. More thorough research on the gigantic water bug's behavioral behaviors was published by J. W. Flosi in 1980 however, those behaviors were not described or classified explicitly<sup>10</sup>.

Capturing, eating and reproductive behaviors (including courtship and parental care behavior) of giant water bugs are the most interesting behaviors that have attracted many scientists worldwide. They prefer larger prey with rich protein content<sup>11</sup>. The

large appetites of the belostomatids have been well-documented: from small invertebrates such as caelifera to big fish, amphibians or large reptiles such as anura, testudines and serpentes...<sup>12</sup>. Shin-ya Ohba (in 2012, 2016), Rankin (in 1935) and Dimmock (in 1887) described how giant water bugs select, “ambush” and ferociously attack their prey: aim and hit a wide variety of targets and only eat the prey they want or easily hunt; when catching prey, they rush into their prey, using their front legs with flexible joints to catch and fix their prey, piercing by the beak and eating the bait<sup>13-16</sup>.

According to R. Smith and Shin-ya Ohba, the giant water bug reproductive season is within summer. The female selects her mate<sup>17</sup>. Their parental care behavior is expressed in males: only male giant water bugs protect, provide moisture and attend to their eggs and nymphs after birth<sup>18,19</sup>. Giant water bug respiratory by using a pair of siphons<sup>20</sup>. Swimming and flight reflexes in giant water bugs were investigated by Dingle as normal locomotion<sup>21</sup>. The giant water bug also has the aggressive behavior of attacking and eating fellow cannibals. This behavior is usually expressed in the adult stage or in conditions of small area or lack of food<sup>22</sup>.

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Severin (in 1911) and Usinger (in 1956) recorded the death-feigning behavior of giant water bugs. When disturbed by removal from water or by contact with the dorsal and ventral surfaces of the body, these bugs assume a characteristic rigid position and remain in this position. This position was maintained for an estimated 17 minutes<sup>23,24</sup>. From 1956 to the present, there has not been any further research on this interesting behavior.

The giant water bug is an attractive species because of its fascinating behaviors and significance to human life and science. In nature, they are considered bioindicators for water and contribute to an important link in the aquatic food web<sup>25,26</sup>. For Vietnamese people and some countries around the world, giant water bugs are culinarily grown, and their essential oils are exploited and used as a medicine source<sup>27,28</sup>. A study on giant water bug behavior contributed to zoology in universities or animal behavior topics in the Vietnam 2018 general education curriculum<sup>29</sup>. Climate change, overexploitation, and changes in culture methods have led to a serious decline in wild giant water bug populations in Vietnam. In 1992, they were listed in Vietnam's Red Data Book as R-Level by Vu Quang Manh<sup>30-33</sup>. In Japan, giant water bugs have also appeared in red books since 2000<sup>34</sup>. To date, there have been no scientific publications showing the recovery of *Lethocerus indicus* in Vietnam.

There has yet to be full and extensive research on the behaviors of giant water bugs in Vietnam. This study contributes to the scientific basis for the raising and conservation of giant water bugs in Vietnam.

## MATERIALS AND METHODS

### Specimens studied

Giant water bug *Lethocerus indicus* was conducted at the Centre for Biodiversity Resources Education and Development's laboratory (CEBRED), P.108, building A2, Hanoi National University of Education, from January to November 2021.

### Experimental design

*Abiotic factor:* Cebred's laboratory is freely connected to the outdoor natural environment in terms of ventilation, light, humidity and temperature. Giant water bugs are reared in rectangular transparent glass tanks with a size of 40x20x30 cm. The water used for the experiment was natural ecological, with a height of 15.0-18.0 cm. The tank is covered with a green metal plate with a mesh size of 2.5-3.0 mm. The tanks are separated by a blue sheet of paper. Resun Aco003 was used for providing oxygen: Wattage = 35 W; P = 0,027

MPa; flow = 70 liters/min. The laboratory is further illuminated by LED bulbs 8718696683118. CRI = 70%; Wattage = 20 W; Luminous flux = 2100 lm, made in Vietnam. We used a 24/24 HiLook camera to indirectly observe the behavioral activities of giant water bugs.

*Biotic factor:* We conducted the experiment with 5 tanks. There are 2 adult giant water bugs, *Lethocerus indicus*, in each tank. Common water hyacinth (*Eichhornia crassipes*: Pontederiaceae) are released into the tank and cover  $\frac{3}{4}$  of the surface the roots are 6.0-8.0 cm long and submerged in the water, and the tops protrude 8-12 cm above the water surface. In each tank, two dried bamboo branches (*Bambusa sp.*: Bambuseae) were placed diagonally to make a substrate 30 cm in length. Giant water bugs are always fully supplied, often including various types of bait from floating on the water and swimming in the water to crawling on the bottom of the water body, such as the superworm (*Zophobas morio*: Tenebrionidae), rohu fish (*Labeo rohita*: Cyprinidae), and the vâ Chinese mystery snail (*Bellamya*: Viviparidae).

All behavioral activities of giant water bugs were recorded on the monitoring sheet in the months from 1/2021 to 11/2021 directly by the researchers 3 times per day.

Behavioral activities are recorded and analyzed on the basis of behavioral science<sup>35,36</sup>. The data were summarized and analyzed using Excel.

## RESULTS AND DISCUSSION

### Identify and describe the behavioral activities of giant water bugs

By monitoring the behavioral activities (BAs) of adult giant water bugs in the laboratory, we defined and described 12 types of BAs:

- BA1: Horizontally floating
- BA2: Diagonally floating
- BA3: Swimming on the water surface
- BA4: Swimming under the water surface
- BA5: Respiration by extension and retraction pair of siphon
- BA6: Capturing and eating prey
- BA7: Vibrating legs
- BA8: Open and flapping wings
- BA9: Clinging to each other
- BA10: Crawling out of water
- BA11: Death-feigning
- BA12: Attacking and cannibalizing each other

These behavioral activities are described in Table 1.



**Figure 1:** *Lethocerus indicus* in the laboratory



**Figure 2:** Tanks for behavioral activities experiment

**Table 1: Behavioral discussion**

| No  | Definition   | Description   | Discussion  |
|-----|--|---|---|
| BA1 | Horizontally floating                                  | Their bodies are free to lie still and sway slightly with the surface water. They can also use both legs at the same time, or one of the left or right legs of the 2nd or 3rd pair, to cling to a fulcrum in the water, which is a dry branch or aquatic plant in the water.  | This activity certain extent, pretending to death of giant water bug. However, they are different in that if lying horizontally on the water, the legs of the giant water bug are still kicking the water or the breathing tube in the tail is still continuously active. When touching the them, they will immediately move to hide. |
| BA2 | Diagonally floating                                    | They cross-legged, silent and half-floating on the surface of the water. They often cling to duckweed, staying at the intersection with the water surface. They use all 3 pairs of legs or one leg to cling to a fixed object.  | This activity usually takes place for a long time from 2 to 3 hours continuously and is the activity that takes place the most and the longest. Cling and float formed diagonal to the water surface line can create a fixed and stable position, giant water bug can easily breathe and easily come into contact with water.         |
| BA3 | Swimming on the water surface                          | They slowly use all their legs like paddles to swim on the surface of the water.  | When they swim on the surface of water, it proves that there is no threat to them such as other animals, or dirty water, etc.   |
| BA4 | Swimming under water surface                           | In this activity, they can swim more slowly when the water environment is not passive or sometimes very panic swimming continuously for a short period of time. This is a behavior activity that does not harm others or other species.   | When they feel threatened, they often swim in the water very quickly to find shelter or sometimes scare their prey or because of some unexpected factor that also leads to them swimming in the water quickly.  |
| BA5 | Respiration by extension and retraction pair of siphon | They use a pair of respiratory siphons that are attached to the external genitalia and anus to respiration. When the bug is submerged, the siphons remain completely retracted under the wings.   | Respiration is always taking place, but it is infrequent to move the siphon when submerge. The increase in temperature may be the reason why they often extension and retraction their siphon tubes at noon.  |
| BA6 | Capturing and eating prey                              | Giant water bug does not pursue their prey, but maintain a relatively fixed position, frequently resting with the respiratory straps breaking the surface film, the middle and hind legs spread, the head slightly forward, and the forelegs spread widely, ready to catch. If they seize the prey, they will hold it firmly. The prey would be captured with the raptorial forelegs. | Having all the aggressive characteristics of the Belostomatidae, hunt and eat in a way that is also very aggressive. The way of eating prey is also characteristic of the species. They certainly secrete an enzyme or fluid to easily absorb the prey and digest them.   |

*Continued on next page*

Table 1 continued

|      |  |  |   |
|------|--|--|---|
| BA7  | Vibrating legs                         | Moving pair of third leg in water or on a surface creates water waves or surface vibrations.   | This innate behavior is often difficult to recognize when observed. Partly because the normal eye has a limited ability to recognize the appearance of waves, partly because they do not often exhibit these behavior activity.   |
| BA8  | Opening and flapping wings             | The outer wing opens, revealing the transparent white inner wings.   | This is an innate behavior in the species. They do not often do this in a stable environment..  |
| BA9  | Clinging to each other                 | The big one crawls up and stays on her body for a while longer or vice versa..   | If we do not pay close attention, we will definitely be confused with the mating. However, the two individuals just crawled over each other, staying on the tree branch, with no other interaction between them. This is when they are most "mellow", not showing their characteristic ferocious nature..   |
| BA10 | Crawling out of water                  | Clinging to a tree branch or water lily to climb and tend to get out of the tank.  | Maybe when they find their surroundings (besides waterweed, which they consider as shelter) safe, they will crawl up. They are very sensitive, so crawling above the water is easier to see with a surveillance camera – when no one is in the lab or too close to the tank.  |
| BA11 | Death-feigning                         | Giant water bug lay motionless on the surface of the water for a long time, approximately 20 minutes, and did not move even though the water surface was agitated. | This activity is easy to confuse with horizontal activity, but in this activity, the stalk will not retract the breathing tube, the legs will not work or in other words lie motionless. This is a rare activity of them. This can be considered as one of their innate self-defense instincts from threats and dangers in the wild.  |
| BA12 | Attacking and cannibalizing each other | They attack each other and eat each other until they die in the same way they catch and eat their prey.  | Due to a few reasons such as the environment that makes them too uncomfortable, the breeding season or strong stimulation they often have cannibalistic behaviors of their own. When the food source is inadequate, hungry for a long time, living in a too crowded environment, they will attack and eat their own kind. They attacking each other is a common thing when observing this animal. They attack the opponent and leave wounds due to their aggressiveness and aggression. However, cannibalism can indicate deterioration of the environment around them. |



**Figure 3:** BA1: Horizontally floating



**Figure 5:** BA3: Swimming on the water surface



**Figure 4:** BA2: Diagonally floating



**Figure 6:** BA4: Swimming under water surface



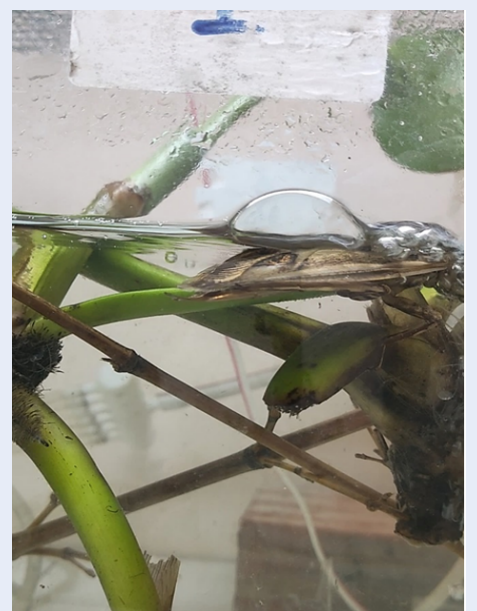
**Figure 7:** BA5: Respiration by extension and retraction pair of siphon



**Figure 9:** BA7: Vibrating legs



**Figure 8:** BA6: Capturing and eating prey



**Figure 10:** BA8: Opening and flapping wings



Figure 11: BA9: Clinging to each other



Figure 13: BA11: Death-feigning



Figure 12: BA10: Crawling out of water



Figure 14: BA12: Attacking and cannibalizing each other

### Classification of behavioral activities

#### Neurophysiological basis of behaviors

Behavioral expressions associated with the development and evolution of the nervous and sensory systems, with a neurophysiological basis, appear only in the animal kingdom, when the nervous system has been formed. The evolution of animals corresponds to the evolution of their nervous systems. Based on the evolutionary system and sensory function of the nervous system, it can be divided into 5 major levels of nervous and sensory evolution:



Group 1: Protozoa: early development of the sensory nervous system. Protozoa have no nervous system and respond to stimuli by body movement or protoplasm contraction.

Group 2: Arthropoda includes Insecta, Arachnida, Crustacea, Molluska, and Echinoderma. They have a complete nervous system and sensory function.

Group 3: Vertebrates with highly developed nervous systems: Fish, Amphibian, Reptile, Bird and Mammal

Group 4: Primates: living as a community, level-classification in simple social.

Group 5: *Homo sapiens*: living in a society with ethical standards.

### Genetical basis of behaviors

(1) Fixed Action Pattern/Instinct = Innate behavior: instinctively determined by genetic factors, from the moment the animal is born, does not need to be learned. This type of innate behavior is associated with the animal's living activities, such as sheltering from adverse biotic and abiotic conditions, foraging and reproducing. These behaviors do not change and are not affected by the environment and living conditions.

(2) Secondary/Learned behavior: through the acquisition of experiences from life and society. These behaviors include activities such as communication, positioning in the herd, and capturing. Some of the most obvious evidence of secondary behavior is the formation of a living colony of highly developed insects, such as ants, bees and termites.

(3) Intermediary behavior: behavior that the animal is born with but will continue to develop and perfect in the individual life of the organism. It is difficult to clearly distinguish between this behavior and secondary behavior.

#### Ecological basis of behaviors

It could be divided into:

- (1) Territory behavior
- (2) Nutrition: hunting, eating behavior
- (3) Courtship, mating behavior
- (4) Parental care behavior
- (5) Social behavior

On a physiological basis, giant water bugs express BA7, BA8, and BA10.

Based on ecologically, giant water bugs express BA6, BA9, and BA12.

On a genetic basis, giant water bugs express BA1, BA2, BA3, BA4, BA6, and BA11.

### Behavioral activity structure

During the experiment, 673 behavioral activities were recorded on the basis of the classification of 12 types of behavior in sections 3.1 and 3.2 of adult giant water bugs. According to Table 2: "Behavioral activities of giant water bug", BA2 (17.24%) was shown the most and most clearly by the giant water bug. BA4 has a rate of 16.94%, which is the second most frequently observed behavior expression in giant water bugs. This was followed by behavior groups BA3, BA5 and BA1, with rates of 15.75%, 14.86% and 12.18%, respectively. Some of the behavioral activities in which giant water bugs are less expressive include behaviors such as BA6 accounting for 11.14%, BA9 accounting for 6.99%, BA7 accounting for 2.97%, and BA8 accounting for 1.34%. Among the 673 behavioral activities of the giant water bug, there were 3 behaviors: BA12 accounted for 0.3%, and BA11 and BA10 had the lowest expression rates, all accounting for only 0.15%.

During the experiment, the artificial ecological environment was maintained as stable, so the behavior expression structure was recorded as relatively stable. Therefore, it is not possible to compare the changes in the axes of giant water bug behavior when their habitat changes.

### Discussion

Through the data on the structure and behavior of giant water bugs (section 3.3), BA2- Cling and float formed diagonal to the water surface line is the BA that occupies most of the time of activity. Based on initial research data, this is the preferred behavioral activity of giant water bugs. Therefore, to create favorable conditions for them to easily live in an artificial environment, the aquarium needs to be provided with waterweed plants and clinging media such as wooden sticks.

The lowest behavioral activity is shown in the two activities of death feigning and crawling out of water (1 expression).

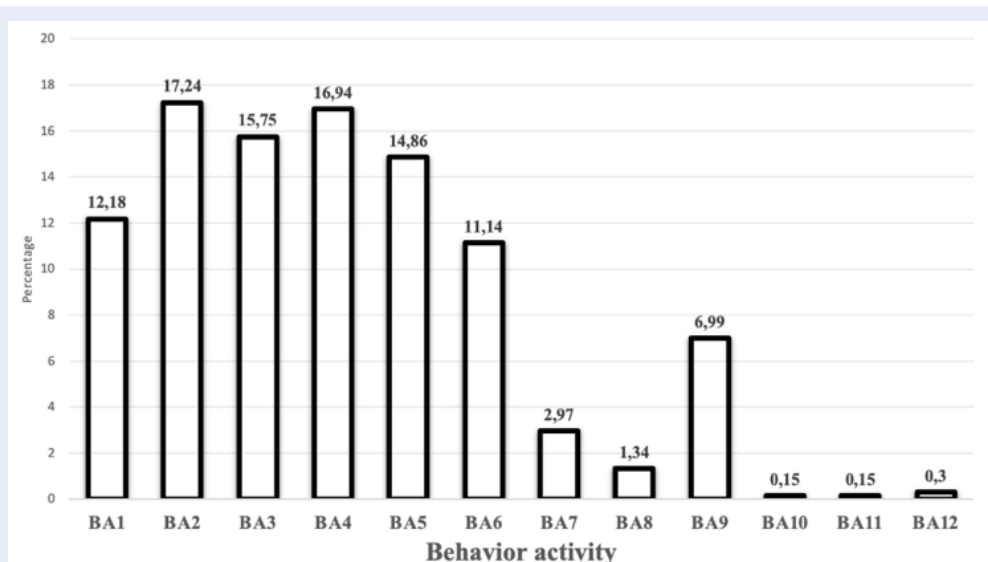
The behavior of capturing and eating bait was expressed a great deal, accounting for a large proportion of the behavioral activities of the species. This is part of the general aggression of this species. Food sources and nutritional habits need to be focused on to best meet the living needs of the species.

### CONCLUSION

We defined and described 12 categories of behavioral activity, including BA1: Horizontally floating, BA2: Diagonally floating, BA3: Swimming on the water

**Table 2: BA structure of giant water bug**

| No     | Amount  | Time | %     | Rank |
|--------|---|------|-------|------|
| BA1    | Horizontally floating                                       | 81   | 12.18 | 5    |
| BA2    | Diagonally floating   | 116  | 17.24 | 1    |
| BA3    | Swimming on the water surface                               | 106  | 15.75 | 3    |
| BA4    | Swimming under water surface                                | 114  | 16.94 | 2    |
| BA5    | Respiration by extension and re-<br>traction pair of saphon | 100  | 14.86 | 4    |
| BA6    | Capturing and eating prey                                   | 75   | 11.14 | 6    |
| BA7    | Vibrating legs  | 20   | 2.97  | 8    |
| BA8    | Openning and flapping wings                                 | 9    | 1.34  | 9    |
| BA9    | Clinging to each other                                      | 47   | 6.99  | 7    |
| BA10   | Crawling out of water                                       | 1    | 0.15  | 11   |
| BA11   | Death-feigning  | 1    | 0.15  | 11   |
| BA12   | Attacking and cannibalizing each<br>other                   | 2    | 0.30  | 10   |
| Total: |   | 673  | 100   |      |



**Figure 15: Behavior structure of giant water bug**

surface, BA4: Swimming under the water surface, BA5: Respiration by extension and retraction pair of siphon, BA6: Capturing and eating prey, BA7: Vibrating legs, BA8: Opening and flapping wings, BA9: Clinging to each other, BA10: Crawling out of water, BA11: Death-feigning, and BA12: Attacking and cannibalizing each other.

These 12 behavioral activities observed descended in the following order: (1) BA2 (17,24%) >(2) BA4 (16,94%) >(3) BA3 (15,75%) >(4) BA5 (14,86%) >(5) BA1 (12,18%) >(6) BA6 (11,14%) >(7) BA9 (6,99%) >(8) BA7 (2,97%) >(9) BA8 (1,34%) >(10) BA12 (0,30%) >(11) BA10 (0,15%) >(12) BA11 (0,15%).

These behavioral activities can be grouped into 3 groups based on their scientific basis: Genetically (92%) >Ecologically (4.5%) >Physiologically (3.5%). This research on the behavioral activities of the giant water bug *Lethocerus indicus* can be considered an important scientific basis to be implemented in the raising and sustainable conservation of the species listed in The Vietnam Red Data Book since 1992.

## ABBREVIATIONS

BA: Behavioral activity  
 BA1: Horizontally floating  
 BA2: Diagonally floating  
 BA3: Swimming on the water surface  
 BA4: Swimming under the water surface  
 BA5: Respiration by extension and retraction pair of siphon  
 BA6: Capturing and eating prey  
 BA7: Vibrating legs  
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 BA12: Attacking and cannibalizing each other

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## AUTHORS CONTRIBUTION

- Develop the research idea, and experimental design: VU (Vu Quang Manh).  
 - Study specimen's sampling in Vietnam: VU and NGUYEN (Nguyen Phan Hoang Anh), and in Laos: PHOMMAVONGSA (Sakkouna Phommavongsa) and VU.  
 - Analyze laboratory samples, and the Study's data: PHOMMAVONGSA, VU and NGUYEN.  
 - Write and complete the manuscript: VU, NGUYEN and PHOMMAVONGSA.  
 All authors read and approved the final manuscript.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript, and all authors have agreed to submit this manuscript to your Journal.

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