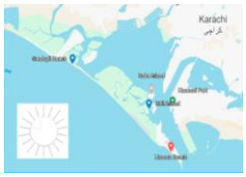

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Comparative Study on the Oothecae of Three Species of Mantodea (Dictyoptera: Insecta)

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ABSTRACT: *During present study, oothecae of three species, namely Hierodula transcaucasica (Brunner von Wattenwyl, 1878), Sphodromantis viridis (Forskal, 1775) and Mantis religiosa (Linnaeus, 1758), were collected and described based on their morphometric characteristics and illustrated features. Significant differences were observed in the dimensions of the oothecae, with S.viridis exhibiting the largest dimensions, measuring 24 ± 0.94 mm in length and 21.6 ± 0.51 mm in width. M. religiosa followed with dimensions of 21.2 ± 0.78 mm in length and 15.3 ± 0.67 mm in width. H. transcaucasica had the smallest length at 17.33 ± 1.23 mm. Additionally, substantial variations in shape and size were noted among the oothecae of the studied specimens. H. transcaucasica oothecae were typically globular in shape, predominantly dark brown with some appearing coffee brown. S. viridis oothecae had a prominently rounded proximal part and a slightly narrower distal end. On the other hand, oothecae of M. religiosa were elongated, typically pale or straw brown, with a thin residual layer. The study recommends the collection and artificial rearing of oothecae as a beneficial approach to promoting mantid culture for potential use as bio-agents in biological control programs.*

Keywords: Carnivores, Pest, Population, Ootheca, Morphometric, Pesticides

INTRODUCTION

Praying mantids, belonging to the order Mantodea, are a diverse group of approximately 2500 carnivorous predatory insects found mainly in warm, humid tropical and subtropical regions worldwide, with rare occurrences in colder areas (Greyvenstein et al., 2020; Otte et al., 2020; Fatimah et al., 2021). They also dwell in the forests, home gardens, pond bionetwork, grassland ecosystem, paddy ecosystem, mango and banana ecosystem (Fatimah et al., 2024). The family Mantidae is particularly rich in mantid species encompassing over 21 families within the order (McMonigle, 2013; Wieland, 2013; Patel and

Singh, 2016; Schwarz and Roy, 2019).They are sternly carnivores predators so they consume lot of agricultural pest insects such as wasps, grasshoppers, aphids, crickets, moths, spiders, beetles, jassids, mealy bugs, termites, white flies and many other small injurious vertebrates viz tiny birds, snakes, lizards etc (Prete et al., 2002; Symondson et al., 2002; Sathe and Patil, 2014; Fatimah et al., 2022). They are furious predators with vital 3-D vision for long distances and because of that they remained very valuable to the agriculturalists and horticulturists in the agronomic sector. In regions of lower Sindh, where pesticides are extensively used year-round, there are significant concerns about their adverse effects on human health, domestic animals and the environment. Pesticides can cause a range of pesticide-related diseases through direct and indirect exposure, including skin blisters, vomiting, cancer, abdominal pain, nausea, eye problems, severe cough, dizziness, and headaches. To mitigate these issues, in the agricultural fields to control pest populations it has been suggested that due to the predatory nature praying mantids proving to be effective bio-control agents against number of pest insects.

The Order Mantodea includes primarily carnivorous insects with diverse hunting capabilities, exemplified by species such as *Humbertiella indica* (Saussure, 1869), *Tenodera attenuate* (Stoll, l877), and *M. religiosa* (Linnaeus, 1758), (Khokhar and Soomro, 2009). Mantids possess unique morphological traits compared to other insects (Sultana et al., 2016), equipped with specialized adaptations for capturing prey, including a triangular head with large compound eyes, an ultrasonic ear, spiky fore raptorial legs, and powerful chewing mouthparts. They are characterized by their distinctive posture of holding their forelegs in a "praying" stance, hence their common name. Praying mantids vary in size from moderate to large, typically ranging from 50-65 mm in length, though some species can reach lengths of 85-90 mm (Harris and Moran, 2000). Their well-developed antennae and robust forelegs with spikes assist in capturing prey (Teyssier, 1997). Their large compound eyes enable them to detect both motionless prey and potential predators (Kral, 2012). While significant research has been conducted on the mantid fauna of Sindh, Pakistan, focusing on their taxonomy and behavior (Fatimah et al., 2016-2020; Fatimah et al., 2022), there remains a gap in understanding the variation and significance of oothecae among different mantid species. This study aims to explore and document these variations, which could contribute to further utilizing praying mantids as effective bio-control agents in agricultural and ecological contexts.

MATERIALS AND METHODS

Exploration of current research was conducted in the Entomological Bio-Control Research Laboratory, Department of Zoology, University of Sindh, Jamshoro during the years 2021-2023 to discover the comparison between the oothecae of three species *H. transcaucasica* (Brunner von Wattenwyl, 1878), *S. viridis* (Forskal, 1775) and *M. religiosa* (Linnaeus, 1758).

RESEARCH STUDY SITES AND SAMPLING

Oothecae were collected from the zones of lower Sindh, Pakistan, with surveys conducted across four different localities: Badin (24.6459^{o} N, 68.8467^{o} E), Tando Muhammad Khan (25.1256^{o} N, 68.5426^{o} E), Thatta (24.7475^{o} N, 67.9106^{o} E), and Karachi (24.8607^{o} N, 67.0011^{o} E), spanning the years 2021 to 2023 (Fig. 1).

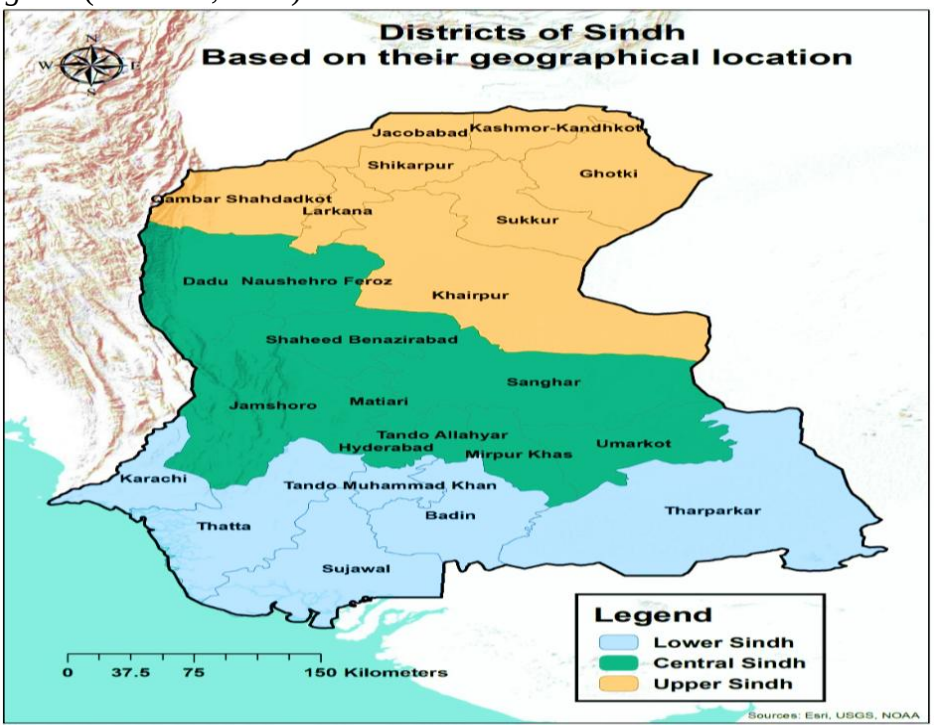

Fig. 1. Representing the Map of Study Areas (Badin, Tando Muhammad Khan, Thatta and Karachi) of Lower Sindh, Pakistan

A total of 276 egg cases (oothecae) were gathered during various months of these years. Locating oothecae proved challenging due to the female mantids' behavior of depositing their ootheca on secure substrates, making them somewhat difficult to spot immediately on plants or trees. The oothecae were carefully collected by hand-picking

or by cutting branches with a sharp knife several inches away from the egg cases to avoid damage. Those attached to walls, boards, lamp posts, or other flat surfaces were removed without harming the egg capsules (Table 1, 2, and 3).

Table 1. Total Number of Collected Oothecae from Fields and Rearing/ Culture

S.NO	*H. transcaucasica*	*S.viridis*	*M.religiosa*
1	4	11	3
2	4	9	2
3	6	9	2
4	8	9	4
5	5	10	8
6	4	8	7
7	3	8	5
8	4	6	5
9	7	6	5
10	5	4	9
11	5	4	6
12	5	4	6
13	9	7	10
14	9	5	5
15	3	11	7
	81	**111**	**84**

Table 2. Total Number of Collected Oothecae

S. No	Species	Mean ± SD (n=15)	Total Number of collected Oothecae
1	*Hierodula transcaucasica*	5.4±1.99c	81
2	*Sphodromantis viridis*	7.4±2.47[a]	111
3	*Mantis religiosa*	5.6±2.35[b]	84
	F. (0.05)	(6.1) 11.34*	276

Mean in the same column followed by the same letters are not significantly different from one another at 5% level of probability.

Table 3. Morphometric Observation on the Oothecae of Various Species of Mantodea

Species	Parameters (Mean ± SD)		
	Length (mm)	**Width (mm)**	**Weight (mm)**
Hierodula transcaucasica	17.33 ± 1.23	15.06 ± 0.70	0.27 ± 0.01
Sphodromantis viridis	24 ± 0.94	21.6 ± 0.51	0.38 ± 0.008
Mantis religiosa	21.2 ± 0.78	15.3 ± 0.67	0.42 ± 0.01

It has been seen from Table 3. The length and width of *Sphodromantis viridis* (Forskal, 1775) was significantly highest i-e 24 ± 0.94mm and 21.6 ± o.51mm respectively followed by *Mantis religiosa* (Linnaeus, 1758) i-e 21.2 ± 0.78 and 15.3 ± 0.67mm. While in the case of *Hierodula transcaucasica* (Brunner von Wattenwyl, 1878) its length was calculated minimum i-e 17.33 ± 1.23mm.

After collection, the oothecae were preserved in jars and warehoused in the laboratory for observation. This meticulous collection method ensured that the oothecae remained intact and suitable for detailed examination of their morphological characteristics and other relevant observations.

PRESERVATION

All plastic jars containing collected oothecae were maintained under controlled laboratory conditions. The temperature was consistently maintained between 39°C to 40°C, while humidity levels ranged from 85% to 92%. To ensure suitable conditions for the oothecae, they were misted with water daily. Upon arrival at the Entomological Bio-Control Research Laboratory, the oothecae were sorted and organized for further study. Observations commenced immediately and continued through the hatching of nymphs, allowing us to document and study the developmental stages and behaviors of the mantid offspring. This controlled environment provided optimal conditions for studying the lifecycle and behavior of the mantids, ensuring that the research could accurately capture and analyze key aspects of their development and ecological interactions.

DESCRIPTIVE STATISTCAL EXPLORATION

The ootheca is an egg case or foamy spongy bag in which the eggs are settle down into the rows. Primarily, at the time of construction it remained foamy in texture and white in color but as soon as contact with air it became hardened and turned into brown or golden brown. So, as it was completely dried the two statistical parameters like length and width

were calculated for analysis. The measurements were taken of field or wild collected as well as oothecae laid by reared species. Different parameters of morphological characteristics such as length (vertically) and width (horizontally) were measured by the help of ruler with measurement scale and geometrical dividers. After taking all the measurements, complete data was calculated by using excel sheet.

RESULTS

The present study focuses on the morphometric characteristics of oothecae from *H. transcaucasica* (Brunner von Wattenwyl, 1878), *S. viridis* (Forskal, 1775), and *M. religiosa* (Linnaeus, 1758), all belonging to the order Mantodea within the family Mantidae. Ootheca easily can be identified by these diagnostic features i-e; Shape, Size, External wall, Texture and color, Point of attachment, Egg chamber, Emergence area (Fig. 2).

MORPHOLOGICAL DESCRIPTION OF OOTHECAE

(A) *Hierodula transcaucasica* (Brunner von Wattenwyl, 1878)

During rearing phase mated female laid 7-9 oothecae (for 09-11 months). Oothecae of *Hierodula* (Deposited as well as wild collected) were ovoid in shape, russet brown in color, soft and spongy in texture with pointed residual process. During fabricating ootheca, it was semi-solid and foamy white in color while after hardening it transformed into brown. The proximal end was wide, oval and the distal end (residual process) was somewhat thin with pointy end. Ootheca grabs 14 transverse and 20-28 longitudinal rows. In the compartments of ootheca, all eggs were horizontally settled into the alignment. Compartments enclosed several eggs in their egg cells (05-400) but number of eggs into the egg case depends on the size of ootheca. Analytically, it was observed that well-nourished female laid massive sized ootheca as compared to low nurtured. Field collected oothecae of this species were also changed in size.

(B) *Sphodromantis viridis* (Forskal, 1775)

Oothecae were puffy, whitish brown at the time of construction. Within time it became hard and gradually changed into dark shimmering or tan, brown, bright prominent rows of compartments about 16-18 ventral and 32-36 dorsal on both sides, rounded or oval frothy along with top of spiky tip. After a few days it became gloomy brown, with brightly pale froth layer; sides were crenelated and emergence area small and concealed majorly in center. The proximal area was much rounded swollen, and the distal area was slightly narrow.

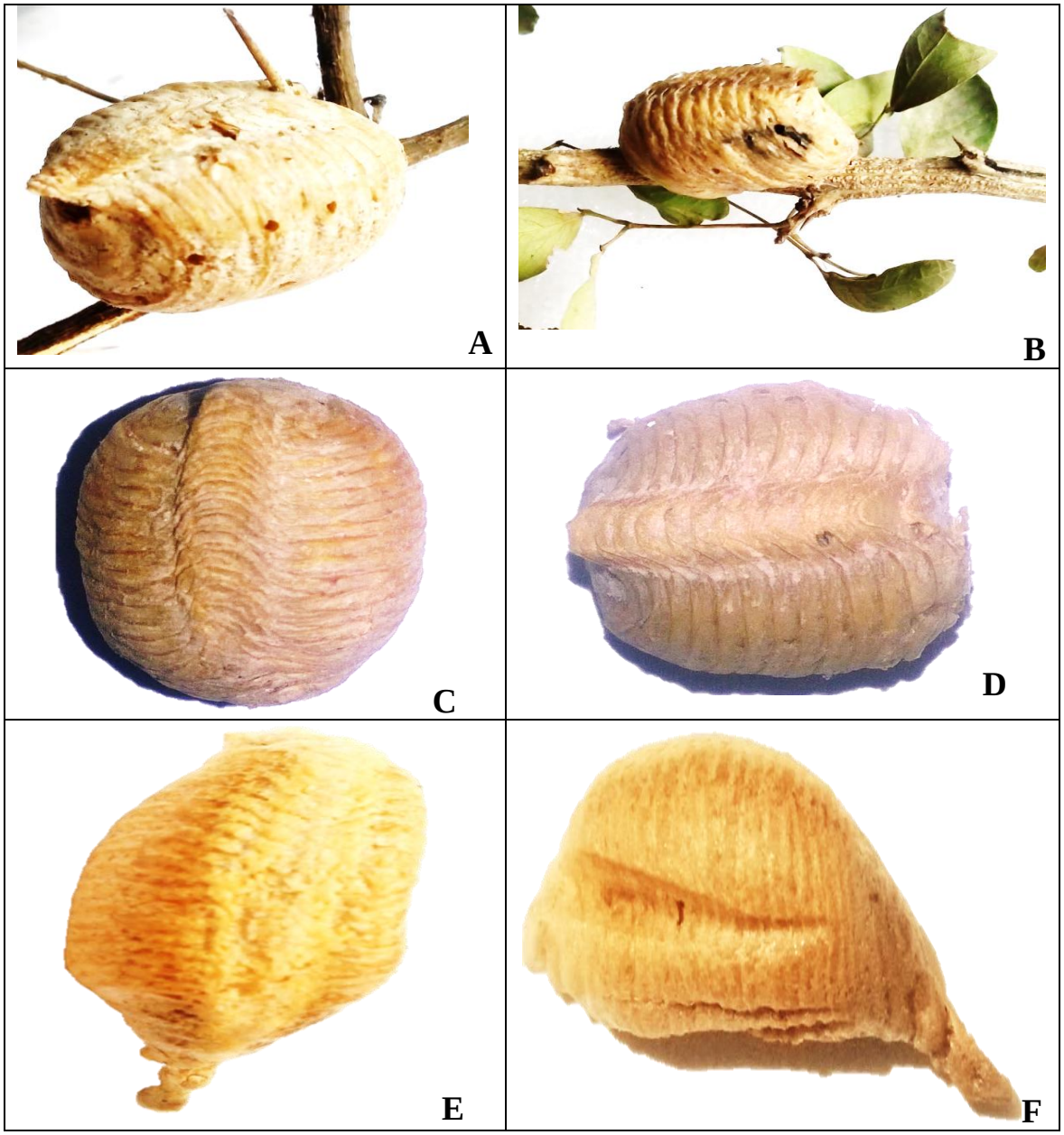

Fig. 2. *Hierodula transcaucasica* Ootheca. A-B, (lateral view); C-D, *Sphodromantis viridis* Ootheca (C, dorsal; D, lateral view); E-F, *Mantis religiosa* Ootheca (E, dorsal; F, lateral view

(C) *Mantis religiosa* (Linnaeus, 1758)

Oothecae were rich, elongated, straw brown with much larger residual layer. About 20-24 slightly proportioned outlines, showed glistening at glance. Two deep depressions or grooves from lateral sides were present. Ootheca was white colored at the time of building within time it became dried out and hard-bitten, initially turned straw yellow and later color transformed into bright whitish

brown. Oothecae were rich, elongated; pale brown with a thin much large residual layer which was somehow lengthy.

DISCUSSION

Morphologic or morphometric refers to the taxonomic quantitative examination of structure that consists of size and shape or it is the technique or process of measuring the external shape and measurement of an organism. Mantids are incredible insects in the insect world which keep distinctive place by showing brilliant habitual behavior of camouflage, head swivel of 180^{o}, ensnaring prey, sexual cannibalism and formation of distinct foamy or spongy type of egg case called "Ootheca". After mating female start producing egg cases in the season of autumn from the month of February to May continuously until she survives (Ramsay, 1990). The varieties of ootheca prominently differs from species to species that type of variation furthermore aids in the identification of species. In the summer season during mating, the male is eaten by female, while approach of female ferocious towards the male as his head come close to her raptorial forelegs shortly, she seizes the male and primarily eat her head. Though mating will continue without the head until her feast is finished. Copulation of mantids is completed in more than a few phases and after or before copulation the female devours the male. After a two-day mating phase, she begins producing an egg case and searching for protective substrates for depositing it, i.e., leaves, trunks, plant stems, shrubs, rocks or walls, or placed in soil or grass and sides of houses. The study displays that the direction of ootheca towards the North, probably to gain ultimate sunlight and heat to accelerating the eggs development (Bowie and Bowie, 2003). Then, well-nourished female with distended abdomen lay eggs in a frothy substance that solidifies into a protective case (Ootheca; plural Oothecae) where eggs remain throughout the winter. Females of some species guard their ootheca while others dump them in sand due to vulnerability of attack from numerous species of parasitic wasps and birds (Ene, 1964; Ramsay, 1990; Vyjayandi, 2007; Weiland, 2008). Adult female *Theopropus elegans* (Westwood, 1832) was observed as guard or protector of her newly laid eggs deposited within an elongated ootheca (Leong and Teo, 2008). An ootheca contain about 200-300 eggs in a bulky shield like case which protect the eggs from unpleasant climatic conditions and enemies. During rearing phase, it was observed that well-nourished females lay large ootheca while under-nourished females will lay small oothecae which contains a small number of eggs. Oothecae vary in size, shape and color (at the time white or creamy or green but after hardening turn into light or

dark brown). The female *H. patellifera* (Serville, 1839) was found depositing her eggs surrounded by a foamy, green ootheca. The ootheca turned hard and became brown within the day because of contact with air (Leong, 2009). Some species of mantids will construct large, round foamy ootheca; some will create short, thick ribbon-like ootheca. Also depending on the species of mantis, some fabricate only one or two ootheca, whereas others can secrete up to twenty during their lives. The entire outer arrangement has an uneven surface, a foam-covered oozing in contact with air rapidly became harden (Avigliano, 2009). Few species attached their oothecae to a flat surfaced area and some enfolded them around the parts of trees or even dumped them into the ground due to the attack of several species of bees or parasitic wasps. Also, it was recorded in a few species, the mother protects their egg cases by guarding them (Ene, 1964). The globular shape of ootheca with pointed end and size depends on the technique of depositing it by *Hierodula* species (Bischoff et al., 2001). The ootheca protects the eggs from microorganisms, parasitoids, predators, and adverse weather. The ootheca preserves a secured water balance through its porous surface and in dry weather protects the eggs against desiccation. In May and June, the eggs hatched steadily after two weeks. The juveniles or immature baby mantids hanged down within a single silk strand out of emerging area of an ootheca. Each ootheca has a compartment-like gap which enclosed tiny valve-like structures from where immatures came out. Both adult as well as nymph are predacious, they are prospective predators because of their weird habits selection for slaying their prey, camouflage for concealment against their own enemies, unique reproductive behavior of cannibalism and enclosing their eggs into the sac (Yadav, 2018).

CONCLUSION

It is concluded that the work on identified oothecae of praying Mantids belongs to the three genera *Hierodula* (Burmeister, 1838), *Sphodromantis* (Stal, 1871) and *Mantis* (Linne, 1758) was not described formerly from the zones of lower Sindh, Pakistan. Furthermore, morphological variance between oothecae were recorded for the first time with their pictures from four diverse areas: Badin, Tando Muhammad Khan, Thatta, and Karachi. This exploration of study provides cherished revelations on taxonomy, biology and diversity of Mantids in Pakistan.

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ETHICAL APPROVAL

No ethical approval is required

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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