NOTES ON THE REPRODUCTIVE BIOLOGY OF *Parastagmatoptera tessellata* SAUSSURE & ZEHNTNER (DICTYOPTERA, MANTIDAE)

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ABSTRACT

Little is known about the reproductive biology and morphology of the oothecae of *Parastagmatoptera tessellata* (Saussure & Zehntner). To contribute to bridge this knowledge gap, different characteristics of egg sacs and nymphs were studied. To this end, egg sacs were collected in the northwest of the province of Buenos Aires, Argentina. A set of eggs was dissected and studied under a magnifying glass to analyze the morphology of the ootheca, and the rest was incubated at room temperature. The following parameters were measured on hatched individuals: duration of hatching, number of individuals hatched per ootheca and duration of the nymphal stage. There were 35.66 ± 8.3 ootheca hatches with a maximum of 45 and a minimum of 24 between the months of October and September. The duration of the nymphal stage is highly variable and it was estimated at 93.03 ± 14.4 days for males and 108.96 ± 17.6 for females. Statistically significant differences were found between sexes.This paper is a contribution to the knowlege of this species, and it is vital to improve breeding efficiency and to pave the way to gaining further insight into this mantid.

Key words: mantids, ootheca, reproductive biology.

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RESUMEN

Poco se conoce sobre la biología reproductiva y morfología de las ootecas de *Parastagmatoptera tessellata*. Con el fin de contribuir a este vacío de conocimiento, se estudiaron y estimaron diferentes características sobre las ootecas y las ninfas. Para ello, se colectaron ootecas en el noroeste de la provincia de Buenos Aires, Argentina. Un lote de las mismas fue diseccionado y se estudió bajo lupa la morfología de la ooteca y el resto se incubó a temperatura ambiente. Sobre los individuos que eclosionaron se tomaron los parámetros: duración del período de eclosión; número de individuos nacidos por ooteca y duración del estado ninfal. Se produjeron 35,66 ± 8,3 eclosiones por ooteca con un máximo de 45 y mínimo de 24 entre los meses de octubre y setiembre. El período de eclosión se mantuvo en un rango de 1 a 5 días. La duración del estado ninfal es sumamente variable y se estimó en 93,03 ± 14,4 días para los machos y 108,96 ± 17,6 para las hembras, y se encontraron diferencias estadísticamente significativas entre sexos. El presente trabajo es una contribución al conocimiento de esta especie, y es fundamental para mejorar la eficiencia en la cría y desarrollar nuevas investigaciones en esta especie de mántido poco conocida.

Palabras clave: mántidos, ooteca, biología reproductiva.

Mantids are found in every warm region of the world, both tropical and subtropical areas, from sea level to 3,000 meters (Agudelo *et al.,* 2007). To date, approximately 2,452 species belonging to 446 genera have been described (Otte & Spearman, 2005; Riviera, 2010). They are popularly known since females may even cannibalize males of the same species during mating (Elgar, 1992). Numerous studies on sexual cannibalism have been made to this day on various species of mantids in order to determine what strategy the male uses when choosing a female to copulate (Maxwell, 1998; 2000; Lelito & Brown, 2006). To this end, Avigliano (2009) and Scardamaglia (2010) used *Parastagmatoptera tessellata* (Saussure & Zehntner) as a model of experimentation in recent years. This species, which is spread over French Guiana, British Guyana, Brazil (at least in Rio Grande do Sul) and Argentina (Agudelo *et al.,* 2007), was described by Saussure & Zehntner (1894). Both sexes are winged. However, females rarely spread their wings to fly, and they do so in defensive and intimidating behavior (pers. com.). Little is known about their reproductive biology and sexual behavior. That is why it is essential to know certain environmental parameters and morphological characteristics of *P. tessellata* in order to contribute to the biological knowledge of this species, and thereby improve efficiency in breeding and deeply understand their sexual behavior. With this objective, some morphological and ecological parameters of this species were studied and estimated, in relation to reproductive aspects such as: 1) morphology of the ootheca, 2) duration of hatching; 3) number of individuals hatched per ootheca and 4) duration of the nymphal stage.

The areas where oothecae are often abundant are those next to the locations where large number of flies are attracted and provide a livelihood to mantids (Guerrero & Cukier, 1981). For this reason, approximately 100 oothecae were collected during the months of June and July 2008 around the Mataderos area in the city of Escobar and in the east and northeast of the province of Buenos Aires (Argentina), namely inBenavidez, Ingeniero Maschwitz, Belén de Escobar and Morón. In addition, oothecae were collected in different neighborhoods of Capital Federal, Argentina, where according to previous studies, oothecae of *P. tessellata* can be found (Avigliano, 2009).

Ootheca morphology. To study the internal and external morphology of the ootheca, 10 samples were submerged in pure water for 10 minutes to moisten and facilitate dissection. Samples were cut in parasagittal and transverse planes using scalpels, needles, scissors and dissection pliers. Subsequently, oothecae were analyzed and both cuts were observed under a stereomicroscope (maximum magnification: 40x) to schematize in parasagittal and transverse planes and in dorsal view.

Total length and width of 71 oothecae were recorded with a VERNIER caliber, model 6914 (accuracy 0.05 mm).

Duration of hatching and number of individuals hatched per ootheca. A total of 20 oothecae were collected and placed individually in 150 ml plastic containers outside the laboratory (temperature between 21–28 °C and humidity between 65–86%) in August 2008. Subsequently, the temporal pattern of hatching was recorded, i.e., time of the year when the nymphs hatch under natural environmental conditions (no temperature or moisture control), the duration of hatching, which corresponds to the time elapsed between the first and the last nymph hatched, and the total number of nymphs hatched per ootheca.

Records were kept on daily observations made at 11 pm, from August 2008 to February 2009. After this period, the oothecae were placed in containers within the laboratory and were monitored weekly for 11 months in order to verify that oothecae did not contain viable eggs.

Length of nymphal stage. The duration of nymphal stage was calculated on 66 mantids hatched in captivity (33 males and 33 females), which were reared to imagines in individual containers of 150 ml volume and fed with *Drosophila sp* flies, *Acheta sp* nymphs and *Tenebrio sp* (mealworm beetle larvae) every two days, according to the methodology of rearing mantids described by Avigliano (2009). The time from insect hatching to their imaginal molt (last molt that determines the transition from nymph to imago) was measured in days; and one factor ANOVA was utilized, with previous verification of its assumptions (Sokal & Rohlf, 1995), to analyze differences between sexes.

Internal and external morphology of the ootheca

The ootheca has an ovoid shape if it is observed dorsally (Fig. 1). Its base, which is the area attached to the substrate (mainly the bark of trees), is flat (Fig. 2, 3) and its transversal section, subtriangular (Fig. 2). The front is tapered, flat and presents a plane process that has a cleavage in "U" in the center while the back is rounded (Fig. 1). The whole structure has a rough texture and originates, as in other mantids, by the hardening of a frothy secretion in contact with air. The oothecae of this species have a milky yellow color when they are constructed and then darken to brown and sometimes grayish brown. As shown in Table 1, considerably more variation was found in the length of the oothecae than in the width (CV length> CV width).

In a dorsal view, external openings of the mantids (Fig. 1) can be identified. These holes line up in two rows located in the direction of the longitudinal axis of the ootheca and located so that each one is in contact with the other two opposite rows, forming a zig–zag pattern (Fig. 1).

In a cross–section it can be observed that each exit point corresponds to a very short chute that is connected to three cells, or triads, located transversely to the longitudinal axis of the ootheca (Fig. 2). Each cell hosts an embryo (Fig. 2). This zig–zag arrangement causes that, in a cross–section, we see that each triad is cut on a different plane, as shown in Fig. 1. In addition, each triad is separated from the opposite by a median septum located sagittally in the ootheca (Fig. 2) and from the external medium by a diaphragm (structure which separates internal from external medium) which is common to the three cells located in the base of each exit opening. This diaphragm does not close the exit to the outside; it is just attached to the median septum of the ootheca and the upper back wall of each cell, as shown in Fig. 2 and 3. Therefore, it works as a hinged door system during the birth of mantids.

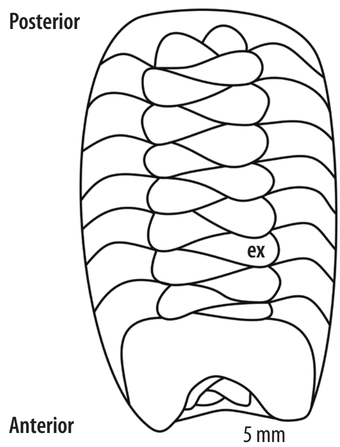

Figure 1. Schematic diagram of the ootheca of *Parastagmatoptera tessellata* (dorsal view). ex, exit.

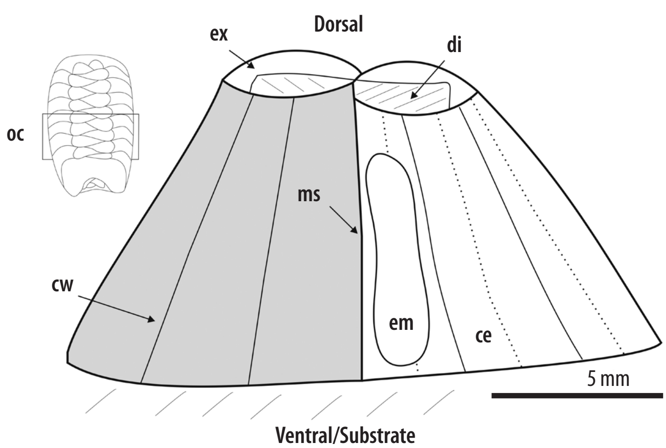

Figure 2. Schematic diagram of the cross section of the ootheca. ce, cell; di, diaphragm; oc, orientation of the cuts; em, embryo; ex, exit; cw, cell wall; ms, median septum. Substrate: tree bark or rocks.

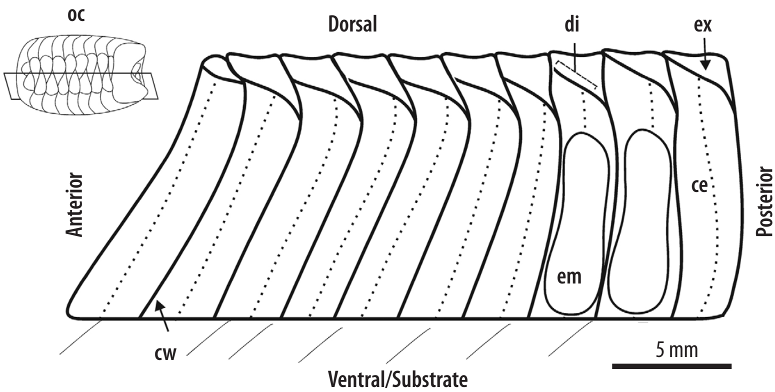

Figure 3. Parasagittal cut of the ootheca. ce, cell; di, diaphragm; em, embryo; oc, orientation of the cuts; ex, exit; cw, cell wall.

	Length (mm)	Width (mm)
Mean	13.77	7.89
SD	1.77	0.46
Range	9.55 – 17.25	6.95 – 9.2
CV	0.13	0.06
$CI_{95\%}$	13.35–14.19	7.87–7.99

Table 1. Measurements of *Parastagmatoptera tessellata* oothecae (n = 71), collected in Buenos Aires province, Argentina. CV, coefficient of variation, CI, confidence interval and SD, standard deviation.

Duration of hatching and number of individuals hatched per ootheca

Births were observed in 6 of the 20 oothecae that were kept at incubation temperature between 21–28 °C and humidity between 65–86%. All hatchings occurred during the months of October and September 2008 (Table 2) 35.66 ± 3.40 (mean ± SD, range: 24–45) nymphs per ootheca were hatched. In half of the cases, hatchings did not occur in a single day, but over a period of 1–5 days. Nevertheless, it can be seen that most nymphs hatched between the first and second day. No nymphs hatched from the other 14 oothecae.

The newly hatched nymphs were yellowish white and their legs extended backwards. Each nymph left the cell where the chorion stood and the wall of the egg. On leaving such cell the first molt occurs, reaching the second nymphal stage. This white molt or exuvia remains attached to the duct exit and it is white. In almost all cases death of nymphs occurred immediately after hatching, but never exceeding 7 individuals per ootheca.

Ootheca	Hatching date	Hatched nymphs/day	Hatching interval (days)	Hatched nymphs/ootheca
1	28/10/2008	27	2	28
	29/10/2008	1		
2	02/11/2008	11	5	24
	03/11/2008	11		
	07/11/2008	2		
3	07/11/2008	41	5	45
	12/11/2008	4		
4	07/11/2008	43	1	43
5	09/11/2008	39	1	39
6	13/11/2008	35	1	35
				Mean= 35.66 ± 3.40

Table 2. Data concerning timing and spacing of hatching, number of births per ootheca and average births per ootheca of *Parastagmatoptera tessellata* (mean ± SD).

Duration of nymphal stage

It was found that the nymphal stage of females is significantly larger than that of males (mean ± SD, 93.03 ± 2.48 days for males and 108.96 ± 3.61 days for females, $F_{1:31} = 16.7$, $p = 0.0001$). The range of variation is rather high, 62 days for males (range: 64–126 days) and 66 for females (range: 80–146 days).

There was a greater variation in oothecae length than in width. The low variation in the width does not affect the number of cells, because in general there are two triads (6 cedae) in cross section. Therefore, the longer oothecae —not the wider— contain more eggs.

As for the hatching temporal pattern of the oothecae of *P. tessellata* that, according to Table 1, is between the months of October and November, it could be said that this data is not representative and of the 20 egg cases used to determine this period, hatching was observed in only 6 of them. One possible reason for this could be that some oothecae contained unfertilized eggs or that these may have hatched earlier. In addition, mantids births were observed under natural conditions during the months of December and January. Therefore, it is possible that if this test were repeated with a higher sample size, the temporal pattern of hatching would extend significantly in January and perhaps by February in these latitudes. Guerrero and Cukier (1981) showed that the temporal pattern of hatching for other species that coexist with *P. tessellata* is broader. For example, it was observed that the hatching of *Coptopteryx gayi* (Blanchard) and *Coptopteryx viridis* (Giglio Tos) takes place between October and December with peaks in late November and early December. Nevertheless, this data should be interpreted with caution as the sample size used to conduct these measurements was extremely small (less than 3 egg cases by species). Furthermore, although these authors performed the study at room temperature with natural light, as they were in a laboratory the data obtained may not be representative since laboratory conditions (light and temperature) may differ considerably from really natural ones. However, this data could be useful for for estimating the hatching seasonal pattern of *P. tessellata* and to schedule collection campaigns of mantids oothecae or adults. It can be said with certainty that the chances of finding oothecae with unhatched eggs would increase if they were collected before the months of September–October in these latitudes.

It was demonstrated that the duration of nymphs is greater in females than in males (Fig. 2). According to our own experience, it is difficult to obtain mantids of both sexes and with similar ages simultaneously to test choice of sexual partner, especially when it is often obtained in captivity sex ratios of 2:1 (female: male) (data not published). In these cases it is of vital importance to take into account that males suffer imaginal molt considerably earlier than females, thus it is possible to calculate in advance the amount of mantids that is necessary to breed on the basis of experiments performed subsequently. In this sense, this work is a significant contribution to understanding this species, and it is essential to improve efficiency in breeding and to develop new research on this mantid species about which little is known.

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References

Agudelo, A.A.R., F. Lombardo & L.J. Jantsch. 2007. Checklist of the Neotropical mantids (Insecta, Dictyoptera, Mantodea). *Biot. Col.* 8(2): 105–158.

Avigliano, E. 2009. Selección sexual en mántidos (*Parastagmatoptera tessellata*): ¿son los machos sensibles a indicadores del estado energético de las hembras? MD. Thesis. Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires.

Elgar, M.A. 1992. Cannibalism: ecology and evolution among diverse taxa, p. 128–155. In: Elgar MA & Crespi BJ, Sexual cannibalism in spiders and other invertebrates, Oxford University.

Guerrero, G.A. & M. Cukier. 1981. Estudio poblacional comparativo de tres especies del género *Coptopteryx* (Dyctyoptera, Mantidae). *Rev. Bras. Biol.* 41(1): 103–110.

Lelito, J.P. & W.D. Brown. 2006. Complicity or conflict over sexual cannibalism? Male risk taking in the praying mantis *Tenodera aridifolia sinensis.* Am. Nat. 168: 263–269.

Maxwell, M.R. 1998. Lifetime mating opportunities and male mating behaviour in sexually cannibalistic praying mantids. *Anim. Behav.* 55: 1011–1028.

Maxwell, M.R. 2000. Does a single meal affect female reproductive output in the sexually cannibalistic praying mantid *Iris oratoria*? *Ecol. Entomol.* 25: 54–62.

Otte, D. & L. Spearman. 2005. Mantida Species File–Catalog of the mantids of the world, *Ac. Nat. Sci. Phil. Insect. Div. Ass. Publ. I.* 489 pp.

Riviera, J. 2010. A historical review of praying mantid taxonomy and systematics in the Neotropical Region: State of knowledge and recent advances (Insecta: Mantodea). *Zootaxa*, 2638: 44–64.

Saussure, H. & L. Zehntner. 1894. Familia Mantidae. *Biol. Centr. Amer. Orth.* 1: 123–197.

Scardamaglia, R.C. 2010. Selección sexual en mántidos (*Parastagmatoptera tessellata*): Efectos del nivel de agresividad exhibido por las hembras en la elección de pareja por parte del macho. MD. Thesis. Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires.

Sokal, R.R. & F.L. Rohlf. *1995. Biometry. 3rd ed. W. H. Freeman. New York, USA, 887 pp.*