

Reproductive phenology of *Cheiracanthium lascivum* (Araneae: Eutichuridae)

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Abstract — Reproductive phenology of Japanese foliage spider *Cheiracanthium lascivum* was investigated on grasslands at Fujisawa City in Kanagawa Prefecture in order to reveal the parity of this species. The individuals overwintered in juvenile stage, made molting nests after April and became adulthood by the mid-June. The females laid their eggs in the breeding nests up to the mid-July. Subsequently, the females and the newborn juveniles dispersed from the breeding nests by the end of July. After the dispersal, we did not observe any type of newly made nest. Although the females' death after reproduction was not confirmed in the natural field, the results strongly indicate semelparous reproduction of this species.

Key words — *Cheiracanthium lascivum*, reproduction, phenology, semelparous, univoltine

Introduction

Evolution of the life history traits is one of the fascinating subjects for biologists. Two major considerations form the foundation for the theory of the evolution of life history traits 1) the sensitivity of fitness to an alteration of the trait and 2) trade-offs among traits (Futuyma 1998). The components of fitness include survival, mating success, and number of offspring. If a species reproduces repeatedly during the individual's lifetime, not reproductive success in a breeding case but lifetime reproductive success is a useful index of fitness under certain circumstances (Cockburn 1991). Consequently, the parity should be taken into account to measure the fitness of certain species in the course of studying the evolution of life history traits.

Previous studies described life history traits of *C. lascivum* and suggested some interesting facts associated with their parity. Hamada (1971) examined the growth rate and estimated the feeding amount of each instar. Kikuchi & Ohkawara (2007) reported that the offspring number was affected by the female size or the nest size. Note that the juveniles' behavior of eating their mother, i.e. matrophagy, is not observed (Kikuchi & Ohkawara 2007). The fact suggests that *C. lascivum* can be an iteroparous species. On the other hand, Rokuta et al. (2009) revealed that the females' egg-laying period was about a month long and the post-reproductive period was less than a month in a laboratory condition. The short post-reproductive period implies that they are semelparous, although the parity of *C. lascivum* in natural fields has not been investigated.

Then, we examined the number of reproduction cycles of

C. lascivum based on field observation to elucidate one of the fundamental life history traits of this species.

Materials and methods

Study animal

Cheiracanthium lascivum Karsch 1879 is known to occur in, Taiwan, Japan, Korea, and the Russian Far East (Yaginuma 1970, 1977; Ono 2009). Recently, its taxonomic position was transferred from the Miturgidae to the Eutichuridae by Ramírez (2014). This spider is a widespread species inhabiting grasslands throughout Japan. Juveniles build their nests for molting, and adults make their nests for mating and/or breeding. The nest is mainly constructed of a monocotyledonous plant leaf bound with spider silk. The form of the nest varies not only with the spider's developmental stages but also according to the spider's usage. Molting nests are built by juveniles for molting into next instars and simple in construction. Mating nests are built by sub-adults for final molting and pre-mating or built by adult pairs for mating. Breeding nests are built by adult females for breeding and rather firmly constructed and larger than the other types of nests. The spider uses several different plant species (the "host plant" noted in Hironaka & Abé 2012) according to the nest type. After mating, the abdomen becomes swollen with the growth of eggs in ovigerous females. Since then, the females lay their eggs in breeding nests and attend their eggs and juveniles until they disperse from the nests as they grow to the second instar. After dispersing from the nests, the juveniles overwinter on grasslands until next spring.

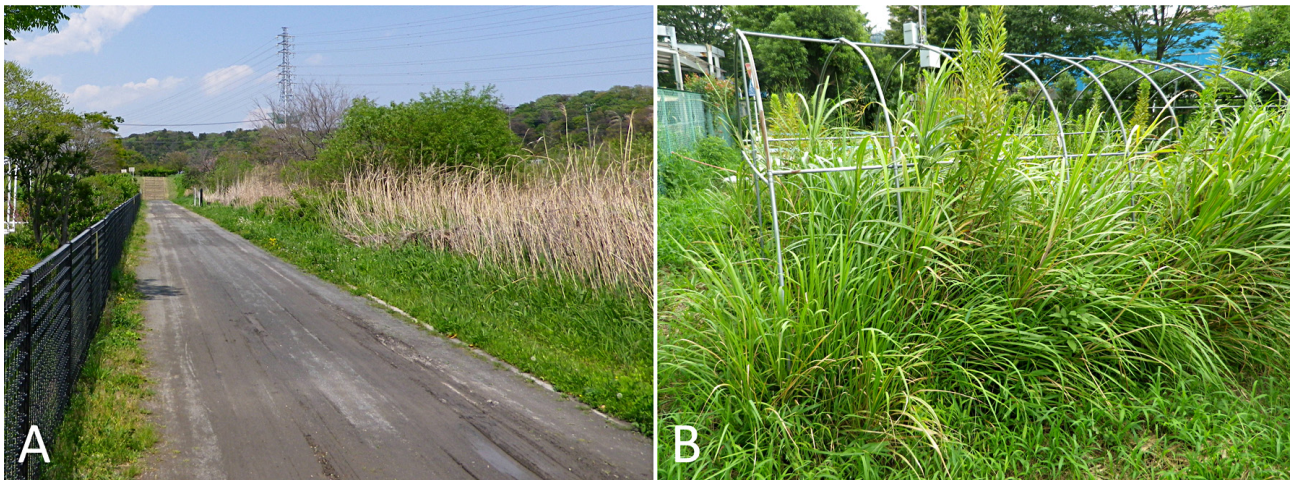


Fig. 1. Study area. A, a grass-covered riparian area at the Hikichi River water garden in Fujisawa City; B, field laboratory cultivated with several poaceous plant species at Nihon University in Fujisawa City.

Study area and period

This study was conducted in a grass-covered riparian area (5 m × 300 m) (Fig. 1A) at the Hikichi River water garden (35°21'N, 139°27'E) in Fujisawa City, Kanagawa Prefecture, central Japan. The area is mainly dominated by poaceous plants such as *Miscanthus sinensis* and *Phragmites australis* in summer. In the study area, the spider's reproductive process is expected to take place from early summer to late summer (Ikeda 1988). Consequently, the investigation was carried out from spring (April) to autumn (October) in 2015. In addition to the natural field observation, a field laboratory (3 m × 5 m) (Fig. 1B) cultivated with several poaceous plant species at Nihon University (35°22'N, 139°28'E) in Fujisawa City was used for continuous observation of the spider's life cycle, especially behaviors of the females and the juveniles during the post-reproductive period, without any accidental artificial disturbance. The field laboratory is placed in a residential area and completely isolated from the natural habitat of *C. lascivum*. Any foliage webbing spiders do not naturally inhabit in the field laboratory.

Observations

To ascertain the number of reproduction cycles of the females, the spatiotemporal transition of the nest conditions in the study area was qualitatively investigated every month from April to October 2015: April 18, 23, 30; May 1, 5, 8, 15, 21, 26, 28; June 1, 4, 10, 23, 24, 25; July 11, 20, 28; Aug. 21; Sept. 5; Oct. 28. In every observation, we recorded the nest type (molting or breeding), conditions (life, death, parasitism, etc.) of the inhabiting spider, and host plant species used for the nest construction. The nest type is judged from the instar of the inhabiting spider and it can also be judged from its form, size and nesting season. The conditions of the inhabiting spider are examined by peeping in through a tiny tear on the nest. In addition to field observation at the Hikichi River water garden, nearly 20

ovigerous females were transported from their natural habitat to the poaceous plant cultivated field laboratory at Nihon University in June 2015. After a building of a breeding nest by the female in the field laboratory, identification number is given to each female. The conditions of the female and her newborn juveniles were observed almost every week until October 2015, when all breeding nests were naturally self-destructed and their recurrences did not observed for more than a month.

Results

Reproductive phenology

Natural field. In natural field, molting nests with the juveniles from fifth to sixth instars were firstly discovered on April 30, 2015 (Fig. 2). Thereafter, the fifth instar juveniles all grew to the sixth instar, and molting nests for the molting to adulthood were observed up to June 10, 2015. Breeding nests with the adult female began to be observed on June 4, 2015, and soon the females laid their eggs in the nests and breeding nests with the female and her eggs were observed until July 11, 2015. Subsequently, the first instar juveniles were hatched from the eggs and then grew to second instar juveniles in the breeding nests. Females and their juveniles were observed in the breeding nests in 20 July, but not in July 28, 2015. Afterward, no newly made nests, females nor newborn juveniles were found in the study area throughout the subsequent observations up to Oct. 28, 2015 (Fig. 2).

Field laboratory. Nearly 20 ovigerous females were transported from the natural field to the field laboratory on June 25, 2015. The next day, 12 breeding nests built by transported females were observed in the field laboratory (Table 1). The females and newborn juveniles were observed in seven out of 12 breeding nests on July 11, 2015. The three other nests were empty, and two nests had been invaded by small ants. No females or juveniles were found in any of the seven breeding nests on July 28, 2015. Afterward, all of the breeding nests were naturally self-

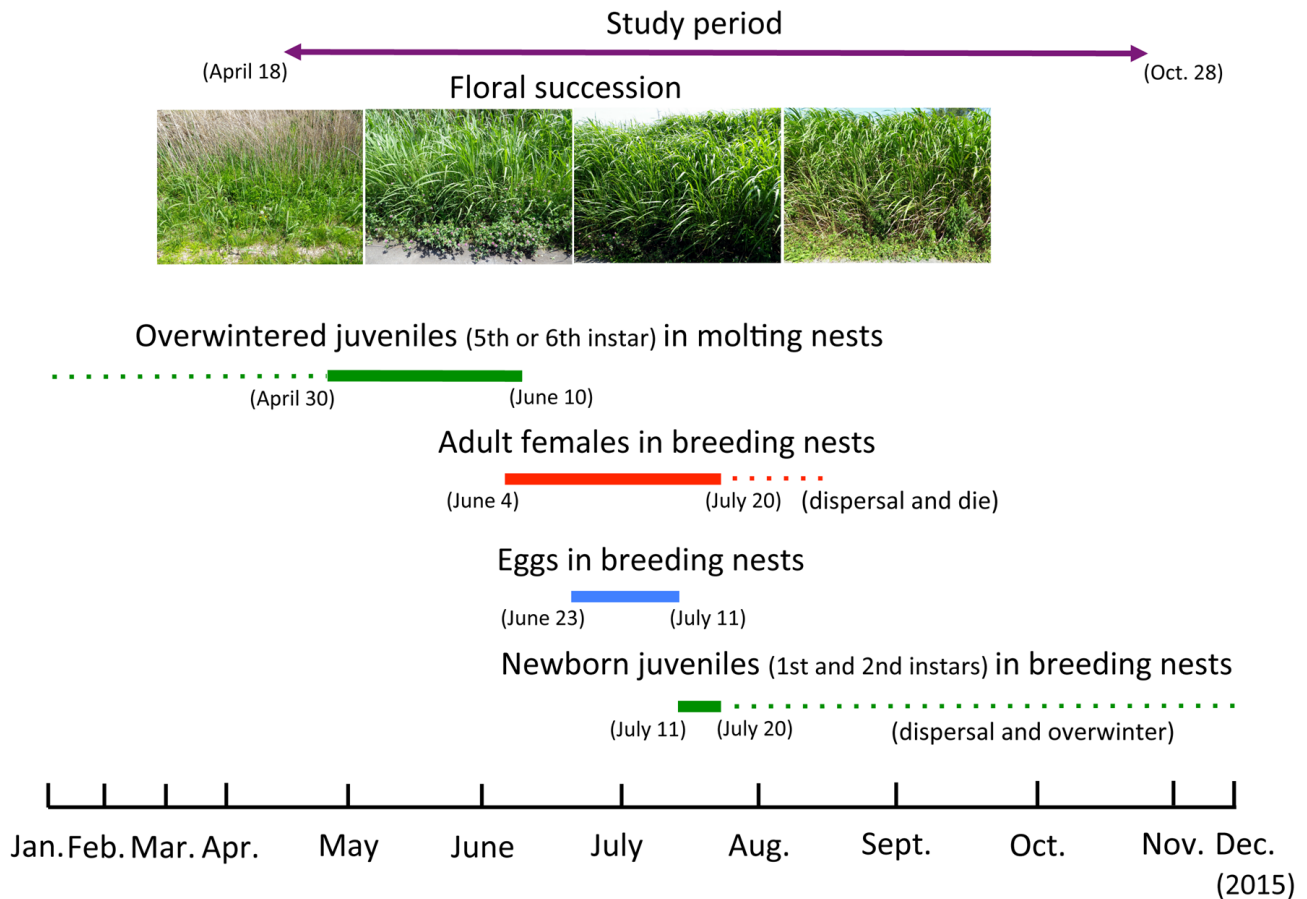


Fig. 2. Transition of the developmental stages of *Cheiracanthium lascivum* in molting and breeding nests at the Hikichi River water garden in Fujisawa City from April to October 2015.

Table 1. Observations after nest building of the ovigerous females transported from their natural habitat to the field laboratory in 2015.

Identification number of the female in the breeding nest	Inhabitant in the breeding nest, nest condition, and nest recurrence						
	June 26	July 11	July 20	July 28	Aug. 21	Sept. 05	Oct. 28
1	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
2	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
3	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
4	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
5	Female	Ants	None	Self-destructed	Non-recurrence	Non-recurrence	Non-recurrence
6	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
7	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
8	Female	Ants	None	Self-destructed	Non-recurrence	Non-recurrence	Non-recurrence
9	Female	None	None	Self-destructed	Non-recurrence	Non-recurrence	Non-recurrence
10	Female	Female and juveniles	None	None	Self-destructed	Non-recurrence	Non-recurrence
11	Female	None	None	Self-destructed	Non-recurrence	Non-recurrence	Non-recurrence
12	Female	None	None	Self-destructed	Non-recurrence	Non-recurrence	Non-recurrence

destroyed, and any kind of nest was not constructed by *C. lascivum* throughout the observations (Table 1). After the dispersal of the females and newborn juveniles from the breeding nests, no more females or juveniles were found in the field laboratory.

Host plants for nest building

The number of plant species making up the flora in the study area was almost stable during the study period. However, the quantitative specific composition of the flora varied with seasonal transition (Photos in Fig. 2). The

juveniles used several kinds of plant leaves for the construction of molting nests (Fig. 3): *Solidago canadensis*, *Trifolium pratense*, *Pueraria lobata*, *Hemerocallis* sp., *Elymus tsukushiensis*, *Sasa* sp., *Miscanthus sinensis*, *Phragmites australis*. At a glance around the field, most of the molting nests in the spring were made of a leaf of the dicotyledonous plants mainly composed of *Trifolium pratense* (Fig. 4 A) and *Solidago canadensis* (Fig. 4 B). However, these two plant species had not been used for the construction of molting nests since June. On the other hand, the adults exclusively used two poaceous plants *Miscanthus*

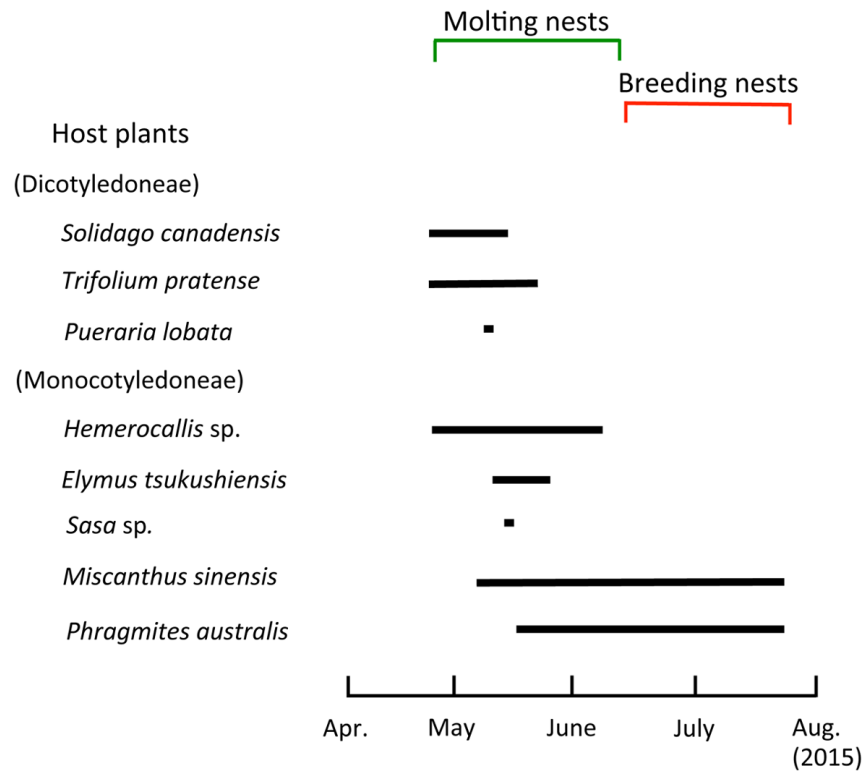


Fig. 3. Composition of host plants used for nest-building of *Cheiracanthium lascivum* in molting and breeding nests at the Hikichi River water garden in Fujisawa City.

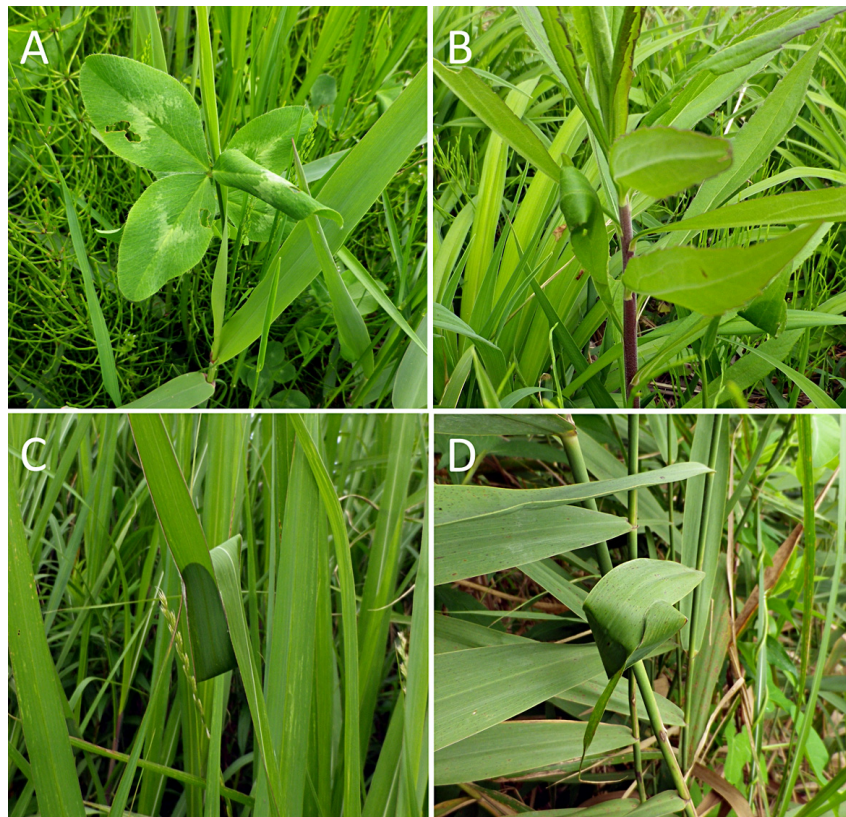


Fig. 4. Host plants used for nest-building of *Cheiracanthium lascivum*. Molting nests: A, *Trifolium pratense*; B, *Solidago canadensis*. Breeding nests: C, *Miscanthus sinensis*; D, *Phragmites australis*.

sinensis (Fig. 4 C) and *Phragmites australis* (Fig. 4 D) for the construction of breeding nests (Fig. 3).

Discussion

As the results of observations of the females' reproductive behavior show, no nests newly made by the females were observed after the females disappeared from the breeding nests since their initial reproduction. The same results were obtained from the observations during the post-reproductive period in natural field as well as in field laboratory in Fujisawa City. Facultative second oviposition as a compensation for the first reproductive failure, which is reported for a crab spider species (Futami & Akimoto 2005) was not observed in the field laboratory.

Although we could not directly observe the females' death after reproduction in the field, the females would not overwinter there, because no nests were built by the females in the forthcoming spring. The following circumstantial evidence strongly indicates semelparous reproduction of *C. lascivum*: 1) no breeding nests were newly made by the females since their initial reproduction, 2) no nests for overwintering were built by the females. This conclusion is also supported by the laboratory observation of females' reproductive behavior in *C. lascivum* by Rokuta et al. (2009). According to Rokuta et al. (2009), the females finally die after a one-month post-reproductive period in the laboratory without a second oviposition. In Kanagawa Prefecture, the egg-laying period of the females was from the mid-June to the mid-July in 2015. The beginning of this period roughly corresponds to the nesting period in which adult females build breeding nests.

The following extrinsic constraints restricting the multiple reproduction of *C. lascivum* are presumable: 1) the females conform the breeding period to the preferable period for using particular plant species to build breeding nests, 2) the time to produce a second brood is lacking for females due to a short favorable season for breeding. However, these extrinsic constraints are inappropriate to explain the semelparous reproduction of *C. lascivum*. Because, the females do not lay eggs even in the artificial nest without using plant leaves after their initial oviposition in a laboratory (Rokuta et al. 2009) and females have a short reproductive period of less than a month in spite of a continuation of

a capable environment for reproduction throughout summer. Unfortunately, evidences are still lacking to elucidate evolutionary history of semelparity for the *C. lascivum*. This subject will be resolved during the comparative study of life history traits of *Cheiracanthium* species in the future.

References

- Cockburn, A. 1991. Studying selection and adaptation. Pp. 85–116. In: Cockburn, A. An Introduction to Evolutionary Ecology. Blackwell Scientific Publications, Oxford etc., 370 pp.
- Futami, K. & Akimoto, S. 2005. Facultative second oviposition as an adaptation to egg loss in a semelparous crab spider. *Ethology*, 111: 1126–1138.
- Futuyma, D. J. 1998. The evolution of life histories. Pp. 561–578. In: Futuyma, D. J. *Evolutionary Biology*. 3rd edition, Sinauer Associates, Inc., Sunderland, 763pp.
- Hamada, R. 1971. Growth rate of *Cheiracanthium lascivum* under laboratory condition. *Atypus*, 55: 2–3. (In Japanese)
- Hironaka, Y. & Abé, H. 2012. Nesting habits of the Japanese foliage spider, *Cheiracanthium japonicum* (Araneae: Miturgidae): host plant preference based on the physical traits of plant leaves. *J. Nat. Hist.*, 46: 2665–2676.
- Ikeda, H. 1988. *Dictionary of Physiology and Ecology of Spiders*. Private Publ., Kanagawa, 173 pp. (In Japanese)
- Karsch, F. 1879. Baustoffe zu einer Spinnenfauna von Japan. *Verh. Naturh. Ver. Preuss. Rheinl. Westfal.*, 36: 57–105.
- Kikuchi, T. & Ohkawara, K. 2007. Factors affecting offspring number of Japanese foliage spider, *Cheiracanthium lascivum* (Araneae: Clubionidae). *Acta Arachnol.*, 56: 91–95. (In Japanese with English summary)
- Ono, H. 2009. Chiracanthiidae. Pp. 464–466. In: Ono, H. (ed.) *The Spiders of Japan with Keys to the Families and Genera and Illustrations of the Species*. Tokai Univ. Press, Kanagawa, 738 pp. (In Japanese)
- Ramírez, M. 2014. The morphology and phylogeny of dionychan spiders (Araneae: Araneomorphae). *Bull. Am. Mus. Nat. Hist.*, 390: 1–374.
- Rokuta, H., Hironaka, Y. & Abé, H. 2009. Life cycle of *Cheiracanthium lascivum* examined by a breeding experiment. *J. ESD Environ. Educ.*, 11: 23–29. (In Japanese with English summary)
- Yaginuma, T. 1970. The spider fauna of Japan (revised in 1970). *Bull. Natl. Mus. Nat. Sci., Tokyo*, 13: 639–701.
- Yaginuma, T. 1977. A list of Japanese spiders (revised in 1977). *Acta Arachnol.*, 27 (Special number): 367–406.

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