

科学研究費助成事業（科学研究費補助金）研究成果報告書

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研究種目：基盤研究(C)
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研究課題名（和文） 巨大精子の形態と化石記録を用いた琵琶湖地域のキプリス上科カイミジンコ類進化の解明
研究課題名（英文） Using giant sperm morphology and fossil data to unravel the evolution of cypridoidean ostracods in the Lake Biwa region.
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研究成果の概要（和文）：私達はこの研究により、キプリス上科カイミジンコの精子で最も短いもの、最も長いもの、そして最も古いものを発見し、これらのカイミジンコの精子の長さや形態学についてのデータを大きく増大させた。本研究の結果はこれらのカイミジンコの精子の長さはずっと約 1000 ミクロンであり、あるグループでは短くなり、他のグループでは長くなったことを示している。

研究成果の概要（英文）：Our research resulted in the discovery of the shortest, longest and oldest cypridoidean sperm known, and greatly expanded the data about sperm lengths and sperm morphology in the superfamily. Our results suggest that a plesiomorphic sperm length for the superfamily may have been around 1000 microns, and sperm lengths have reduced in one group, and increased in others.

交付決定額

(金額単位：円)

	直接経費	間接経費	合計
2010 年度	900,000	270,000	1,170,000
2011 年度	600,000	180,000	780,000
2012 年度	500,000	150,000	650,000
年度			
年度			
総計	2,000,000	600,000	2,600,000

研究分野：生物学

科研費の分科・細目：基礎生物学、生物多様性・分類

キーワード：進化 化石 カイミジンコ 形態 巨大精子

1. 研究開始当初の背景

Ostracods are the most abundantly preserved arthropod in the fossil record and this gives them a remarkable advantage over many other groups when studying evolutionary processes. Ostracods of the superfamily Cypridoidea, such as those found in Lake Biwa, also have an unusual biological characteristic, namely giant sperm (e.g. Wingstrand, 1988; Matzke-Karasz, 2005). Such sperm has been reported to be up to 10 mm in length (Bauer, 1940). The evolution and speciation processes of ostracods in Lake Biwa (and other ancient lakes) cannot be fully understood without an understanding of their reproductive methods. The function and evolution of giant sperm is thus central to this point, but further research in this area was hampered by a lack of data for modern ostracod sperm.

Within the field of giant spermatozoa research, the international trend has been to focus on the fruit fly genus *Drosophila*, a taxon with spermatozoa up to 60 mm in length (Pitnick et al., 1995). In contrast, giant spermatozoa in ostracods it is very poorly studied, especially the variation in morphology.

The Lake Biwa region provides an excellent field study area to determine the processes of evolution within cypridoidean ostracods due to its long lacustrine history and abundant and diverse modern fauna.

Bauer, H. 1940. Über die Chromosomen der bisexuellen und der parthenogenetischen Rasse des

Ostracoden *Heterocypris incongruens* Ramd. Chromosoma, 1, 620–637.

Matzke-Karasz, R. 2005. Giant spermatozoon coiled in small egg: fertilization mechanisms and their implications for evolutionary studies on Ostracoda (Crustacea). Journal of Experimental Zoology (Mol Dev Evol) 304B: 129–149.

Pitnick, S., Spicer, G. S., & Markow, T. A. 1995b. How long is a giant sperm? Nature, 375, 109.

Wingstrand, K. G. 1988. Comparative spermatology of the Crustacea Entomostraca. 2. Subclass Ostracoda. Biologiske Skrifter 32, 1–149.

2. 研究の目的

The purpose of the research was to expand the data available on Cypridoidea sperm, in order to provide a basis for unraveling the evolution and function of giant sperm in the taxon. In conjunction with this data, fossil material provides a framework in which evolutionary hypotheses can be tested.

3. 研究の方法

Specimens were dissected and photographs of the carapace, Zenker organs, and sperm (up to 20 sperm if possible) were made for each specimen. The photographs were then uploaded to a computer running “ImageJ”, an image analysis application, and measured. For each sperm, the lengths of both the anterior and posterior regions were made. The data was transferred to

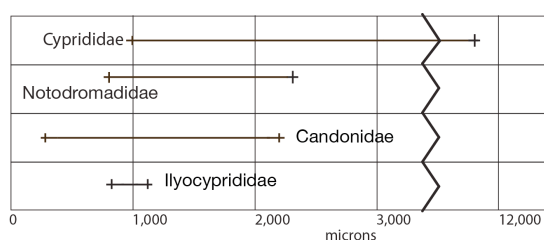
Microsoft “Excel” for further analysis.

For fossil material from Shiga Prefecture, drill tailings from the Katata Formation were broken down using hot water, and the resulting residues sieved and dried. From the residues fossil specimens were picked with the aid of a dissecting microscope.

For fossil material from the Riversleigh World Heritage Site, the specimens donated were already processed and picked. These consisted of over 800 specimens, which were analyzed under a binocular microscope for potential soft part preservation. Chosen specimens were taken to the European Synchrotron Radiation Facility for synchrotron microtomographies and data processing.

4. 研究成果

The total length of sperm and the lengths of the anterior and posterior regions of sperm of 51 species of Cypridoidean ostracods were recorded.



Ranges of sperm lengths of the four families in the Cypridoidea.

All sperm studied were at least 1/3 the length of the male that produced it, demonstrating that sperm is constantly oversized in the superfamily; no short sperm, as seen in other ostracods groups, indicates that long sperm are essential for reproduction in this taxon.

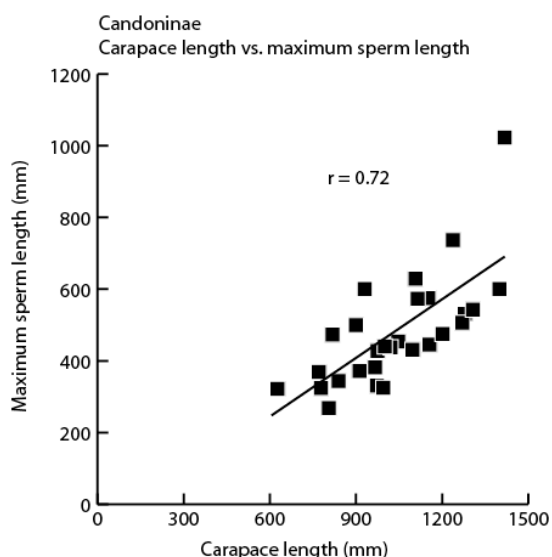


Sperm of *Fabaeformiscandona velifera*, 237 microns in length. This species has the shortest sperm known in the superfamily, but is still 1/3 the length of the male.

The reasons for this are unclear, but it indicates that the reproduction with giant sperm in ostracods is quite different from that of the fruit-fly genus *Drosophila*, in which species with short sperm as well as giant sperm exist. All four families in the superfamily have species with sperm about 1 mm in length, and we postulate that this may be a plesiomorphic length for the Cypridoidea. Some groups, such as the diverse candonids, which includes the 12 *Fabaeformiscandona* species living in Lake Biwa, have possibly reduced the length of their sperm over time. Other groups, especially some Cyprididae subfamilies and the Notodromatidae subfamily Oncocypridinae have probably increased theirs over time. Really long sperm, more than twice the length of the male, appears to have evolved several times in different taxa.

Overall, there is no significant correlation between sperm length and

carapace length, indicating that larger males are not necessarily producing longer sperm. Within the subfamily Candoninae, however, there is a correlation between carapace length and sperm, indicating that larger males do produce longer sperm.



For each sperm used in the study, the posterior and anterior regions were also measured. The anterior region ranged from 8 to 66% of the total length of the sperm, but was not observable in two species. The research also resulted in new methods for the recovery of sperm from ostracods.

The samples of the Katata Formation of Shiga Prefecture yielded only a small number of fossil specimens, mostly poorly preserved juveniles. However, three genera were recovered, namely *Fabaeformiscandona*, *Pseudocandona* and *Physocypria*.

To compensate for the lack of good quality and diverse fossil faunas from the Shiga Prefecture region, specimens of fossil freshwater ostracods from the Miocene Riversleigh fossil locality in Australia were utilized. Over 800 specimens were made

available for study, and this led to the discovery of 26 specimens with soft part preservation. A full taxonomic study of this material resulted in three new species being described, plus a detailed analysis of the paleo-environment and fossilization processes. This material was further studied with synchrotron radiation, which resulted in the discovery of fossil sperm preserved in a couple of the specimens. These highly unusual and rare results provided a unique opportunity to compare the fossil sperm with the sperm from living counterparts to determine the amount of evolutionary change in Cypridoidea sperm over tens of millions of years.

5. 主な発表論文等

(研究代表者、研究分担者及び連携研究者には下線)

[雑誌論文] (計 10 件)

- ① Matzke-Karasz, R., Neil, J. V., Smith, R. J., Godthelp, H., Archer, M. & Hand, S. J. Ostracods (Crustacea) with soft part preservation from Miocene cave deposits of the Riversleigh World Heritage Area, NW Queensland, Australia. *Journal of Systematic Palaeontology*, 査読有、2013.
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- Ostracoda on the Iberian Peninsula? *Journal of Crustacean Biology*, 査読有、Vol. 32、2012、pp.949–961.
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- ⑤ Horne, D. J., Curry, B. B., Delorme, L. D., Martens, K., Smith, A. J., & Smith, R. J. OMEGA: the Ostracod Metadatabase of Environmental and Geographical Attributes. *Joannea Geologie und Paläontologie*, 査読有、11、2011、pp.80–84.
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- ⑦ Rompa, S., Matzke-Karasz, R. & Smith, R. J. Technical dissection aspects for obtaining giant sperm. *Joannea Geologie und Paläontologie*, 査読有、11、2011、pp.165–167.
- ⑧ Smith, R. J. Groundwater, spring and interstitial Ostracoda (Crustacea) from Shiga Prefecture, Japan, including descriptions of three new species and one new genus. *Zootaxa*, 査読有、3140、2011、pp.15–37.
- ⑨ Smith, R. J., Janz, H. & Okubo, I. Recent Cyprididae and Ilyocyprididae (Crustacea: Ostracoda) from Lake Biwa, Japan, including a summary of the lake's ostracod fauna. *Zootaxa*, 査読有、2874、2011、pp.1–37.
- ⑩ Smith, R. J., Matzke-Karasz, R. & Kamiya, T. Lengths of Cypridoidean (Ostracoda, Crustacea) spermatozoa. *Joannea Geologie und Paläontologie*, 査読有、11、2011、pp.189–190.
- [学会発表] (計4件)
- ① Horne, D. J., Curry, B. B., Delorme, L. D., Martens, K., Smith, A. J., & Smith, R. J. OMEGA: the Ostracod Metadatabase of Environmental and Geographical Attributes. 7th European Ostracodologists' Meeting, 2011年7月27日, グラーツ、オーストリア
- ② Matzke-Karasz, R., Smith, R. J., Neil, J. V., Godthelp, H., Archer, M. & Hand, S. J. Preliminary report on early Miocene freshwater ostracods (Crustacea) with soft part preservation from the Riversleigh site, NW

Queensland, Australia. 7th European Ostracodologists' Meeting, 2011年7月25日, グラーツ、オーストリア.

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④ Smith, R. J., Matzke-Karasz, R. & Kamiya, T. Lengths of Cypridoidean (Ostracoda, Crustacea) spermatozoa. 7th European Ostracodologists' Meeting, 2011年7月25日, グラーツ、オーストリア

[図書] (計0件)

[産業財産権]

○出願状況 (計0件)

○取得状況 (計0件)

[その他]

6. 研究組織

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