学　位　論　文　要　旨

The adaptive significance of asynchronous hatching and filial cannibalism in the burying beetle, *Nicrophorus quadripunctatus*
ヨツボシモンシデムシにおける非同調孵化と子殺しの適応的意義

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Paternal care including food provisioning has evolved in many animal lineages. Parental care increases the fitness of offspring by investing some parental expenditure (time, energy or other resources) called parental investment. The optimal levels of parental investment can be found at the point at which they experience greatest benefit for least cost. In general, the optimal level of parental investment for offspring is greater than that of its parent. The disparity between the optimal levels of parental investment for parent and offspring generates evolutionary conflict, which is called parent-offspring conflict. In principle, parent-offspring conflict selects offspring to develop mechanisms to increase total amount of parental investment to current reproduction and skew parental investment towards the offspring, whereas parent-offspring conflict selects parents to develop mechanisms to withhold parental investment. Recent studies have demonstrated the out come of co-evolution between parents and offspring. In some species, parents control the amount of parental investment, whereas in other species, offspring control the amount of parental investment. However, there is currently no information on what kind of ecological and physiological conditions affect the out come of co-evolution between parents and offspring.

In the present study, the author focused on hatching pattern of offspring and filial cannibalism by parents, both of which potentially influence total amount of parental investment to current reproduction and allocation of resources to individual offspring. Asynchronous hatching refers to the time span across which a clutch hatches, from the hatching of the first egg to the hatching of the last egg. In asynchronous hatching species, early and late hatching offspring obtain different amount of parental investment. Thus, the age composition of offspring established by asynchronous hatching may influence total amount of parental investment to current reproduction. Filial cannibalism is the act of eating one's own offspring. Parents can save the amount of parental care to

current reproduction by cannibalizing some of their offspring. Thus, filial cannibalism can also influence the amount of parental investment to current reproduction. Here, the author investigated the role of asynchronous hatching and filial cannibalism in the regulation of the amount of parental investment, to understand the adaptive significance of asynchronous hatching and filial cannibalism. In the present study, the author investigated the burying beetle *N. quadripunctatus*, a species in which the parent can eliminate less-adaptive offspring (e.g. slower-growing offspring) by filial cannibalism and adjust the age structure of offspring to adaptive pattern.

First of all, the author investigated how the point in time at which each group of larvae hatched affects filial cannibalism by the female parent. The main aim of the present study was to determine the age composition of offspring that survived and to determine the effect of larval growth on filial cannibalism. The author found that *N. quadripunctatus* exhibited asynchronous hatching, and reared larvae of different ages. Furthermore, the larvae hatching at latter intervals had lower survival and growth rates; therefore, filial cannibalism plays a role in eliminating later-arriving, slower-growing, and hence less-adaptive offspring.

Secondly, the author investigated the influence of hatching patterns on offspring growth and survival, to demonstrate how hatching patterns affects the allocation of parental investment. The author found that asynchronous hatching pattern, in which hatching of offspring is skewed towards the earlier part of hatching period, maximizes offspring growth and survival. Additionally, hatching patterns had a significant effect on growth of individual offspring. Thus, the present study demonstrates that asynchronous hatching pattern maximizes offspring growth and survival by affecting the allocation of parental investment.

Thirdly, the author investigated the adaptive significance of filial cannibalism by male parent. Filial cannibalism by males could be adaptive if males are able to selectively cannibalize unrelated offspring. Here, the author investigated the stage at which male burying beetles, *N. quadripunctatus*, increase their paternity by evaluating the number of offspring sired by a nursing male in asynchronously hatched broods in relation to hatching time. The author found that nursing males assure a very high level of the paternity of hatching offspring. The paternity of non-nursing and nursing males remained constant across hatching time within a brood, indicating that it is unlikely that filial cannibalism plays a role in increasing the paternity of offspring. Thus, ensuring paternity before fertilization is more important in increasing the paternity of offspring.

The findings obtained from the present study provide important insights into the mechanisms to regulate the amount of parental investment and the outcome of parent-offspring conflict. The present study demonstrated that parents can regulate the amount of parental investment to current reproduction by two different ways, (1) by regulating the number of offspring by filial cannibalism, (2) by affecting the allocation of parental investment by asynchronous hatching. These mechanisms set up the level of offspring competition and allocation of parental investment among them, and offspring cannot affect these mechanisms. In contrast to parents, offspring can increase the amount of parental investment only by soliciting more investment. Thus, even if offspring can increase the amount of parental investment by soliciting more investment, parents can control the total amount and allocation of parental investment. The existence of these superior regulation mechanisms may contribute to parental control of the amount of parental investment.