

氏 名 小川 裕理

学位(専攻分野) 博士(理学)

学位記番号 総研大甲第 1619 号

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学位授与の要件 先導科学研究科 生命共生体進化学専攻
学位規則第6条第1項該当

学位論文題目 The physiological basis for color vision in the Eastern Pale
Clouded yellow butterfly, *Colias erate*

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論文内容の要旨

The candidate, Yuri Ogawa, analyzed the spectral organization of the compound eye of the Eastern Pale Clouded Yellow butterfly, *Colias erate*. Several original discoveries are described in detail in subsequent chapters in generally well-written English. The thesis begins with the General Introduction, which is followed by three main chapters (Chapter I-III), and concludes with the General Discussion and Conclusion. The results are highly convincing because several different experimental approaches were employed in a well-balanced manner: the experimental techniques include intracellular and extracellular electrophysiology, anatomy, molecular biology, microspectrophotometry and computer simulation.

In the General Introduction, the history of color vision research in insects is summarized, with special emphasis on the studies in butterflies, whose compound eyes are often rather complicated in terms of spectral organization. After briefly summarizing the eye properties of some pierid species, the reason why the candidate selected *Colias erate* (Pieridae, Coliadinae) as the model system is explained.

In Chapter 1, the regionalization and sexual dimorphism of the *Colias* eye is described based on optical analysis using the tapetal reflection and spectral sensitivity as determined by electroretinographic methods.

Chapter 2 focuses on the mechanisms underlying the various middle wavelength-absorbing (M) receptors. The key finding in this chapter is the existence of an opsin of a blue-absorbing visual pigment, CeB, in addition to the four previously-identified visual pigment opsins. With the newly discovered CeB, the spectral characteristics of all the M receptors are well described. The contents of Chapter 2 were published as an original article in the *Journal of Comparative Physiology A*.

Chapter 3 focuses on the pronounced sexual dimorphism of red receptors: males have red receptors all peaking at 660 nm, while those of females can peak at 620, 640 or 660 nm. The variety was attributed to the filtering effects of the sexually dimorphic perirhabdomal pigments. Ms Ogawa went on to simulate the wavelength discrimination ability of *Colias*, using the noise-limited color opponency model, and compared this between sexes as well as with *Pieris rapae*, whose eye organization has been well described previously. The contents of Chapter 3 have been submitted

to the Journal of Experimental Biology as an original article, which is currently under revision.

The thesis is concluded by the General Discussion and Conclusion, with remarks on the biological/evolutional significance of the described eye regionalization and sexual dimorphism. Finally, the contents of the entire thesis are informatively summarized.

博士論文の審査結果の要旨

This thesis contains several novel findings, which represent substantial contributions to the fields of neuroethology, sensory ecology, visual neuroscience, evolutionary biology and related areas. Because the thesis is written in English, the committee concluded that the candidate's English proficiency is satisfactory. The thesis achieves a high standard of merit, and the all members of the committee agreed that it is satisfactory for a PhD.

Yuri Ogawa first gave a 45 min lecture, which was open to the public, outlining her thesis. The audience asked several questions of the candidate after the lecture. Most questions were specifically related to the contents of the thesis, and the candidate gave reasonable answers. The entire examination was carried out in English.

After the lecture, the committee members held a closed oral examination. All members asked some general as well as specific questions. The questions covered a wide range of topics including methodology, modeling, molecular evolution and visual ecology. The candidate made considerable effort to discuss these issues with the committee members. The oral examination indicated that the candidate has acquired a sufficient body of knowledge in the fields of neuroethology, sensory ecology, visual neuroscience, evolutionary biology and related areas. Her English ability is also satisfactory.

The committee members all expressed their satisfaction with the quality of the work reported in the thesis, its novelty, the overall approach, and the quality of presentation. In conclusion, the committee members all agreed that Yuri Ogawa had successfully passed the thesis examination for receiving the Doctor of Philosophy (Science).