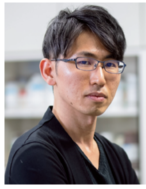
Biodiversity conservation, Medical & healthcare

Analysis of the neural mechanism in the brain that senses the season based on the circadian clock



Department of Biological Sciences, Graduate School of Science
Assistant Professor Masaharu Hasebe
Researchmap https://researchmap.jp/masaharuhasebe

Abstract

Many animals sense the season based on photoperiods, and adequately modulate physiological functions and behaviors. The circadian clock, which forms about 24-hour rhythms, is suggested to be important for the photoperiodic responses. However, cellular photoperiodic responses in the brain that controls physiology and involvement of clock genes in the cellular responses have been elusive. Here, we demonstrated that oviposition-promoting neurons in the brain drastically changed their neuronal activity according to day-length conditions by using the bean bug *Riptortus pedestris*. Additionally, we also found that the photoperiodic neuronal response was attenuated by gene knockdown of the clock gene.

Background & Results

Organisms living in temperate regions adapt to seasonal environmental changes by modulations of physiological functions, such as reproductive functions, nutrient accumulation, temperature tolerance. Many organisms sense the season from changes in the day length. It is suggested that the circadian clock, which is a biological clock that forms about 24-hour rhythms, plays an important role in measuring the day length. Since the proposal of a model for circadian rhythm-based photoperiodic time measurement by plant physiologist Erwin Bünning in 1936, analysis of the central mechanism has been underway for many years.

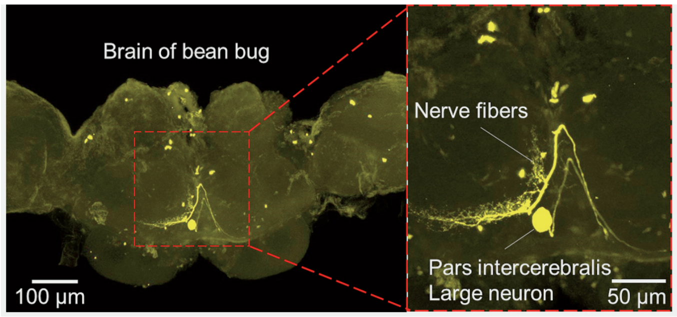
Recent studies using genetic engineering techniques have shown that circadian clock genes are important for the photoperiodic responses in some physiological functions, such as the reproductive function. However, it was unclear whether the circadian clock genes contribute to the photoperiodic responses at the cellular level in the brain that controls physiological functions.

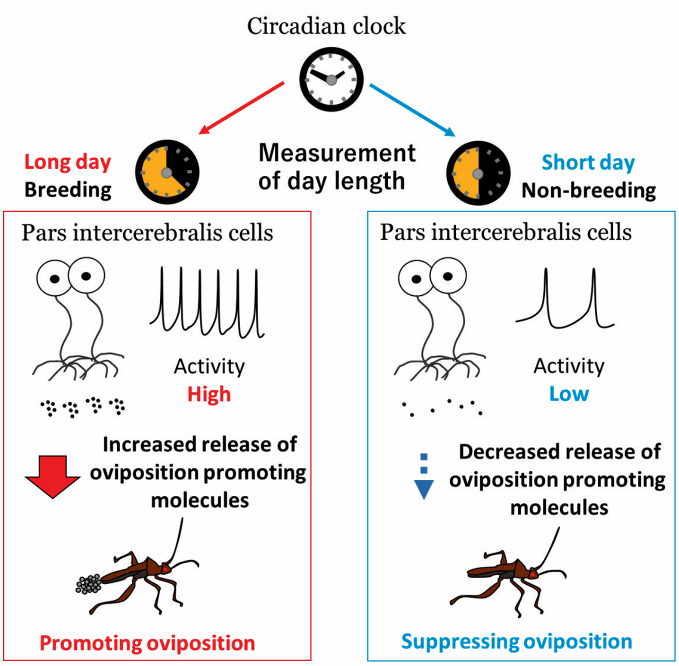
Here, we analyzed the cellular photoperiodic response based on the clock genes by using the bean bug *Riptortus pedestris*, which shows clear photoperiodic responses in the reproduction. Electrophysiological analyses revealed that large neurons in the pars intercerebralis drastically change their neuronal activity according to day-length conditions. Additionally, by applying the RNA interference-mediated gene knockdown, we also demonstrated that the knockdown of the clock gene abolished the photoperiodic neuronal response. Finally, we analyzed the physiological role of pars intercerebralis neurons using molecular genetic techniques, and found that pars intercerebralis neurons express multiple neuropeptides which contribute to promoting oviposition.

The present results suggest that the clock gene plays an essential role in the cellular photoperiodic response in the oviposition-promoting neurons.

Significance of the research and Future perspective

Photoperiodic responses based on the circadian clock are important for seasonal adaptation in various organisms. In the present study, by combining cellular analysis and gene manipulation, we succeeded in demonstrating that the circadian clock gene is important for the photoperiodic responses at the cellular level. By applying the present combination-analysis, it is expected that the photoperiodic response mechanism based on the circadian clock in various species will be clarified.





Patent

Treatise Hasebe, Masaharu; Shiga, Sakiko. Oviposition-promoting pars intercerebralis neurons show period-dependent photoperiodic changes in their firing activity in the bean bug. Proceedings of the National Academy of Sciences of the United States of America. 2021; 118(9): e2018823118. doi: 10.1073/pnas.2018823118

URL https://resou.osaka-u.ac.jp/ja/research/2021/20210224_1

Keyword seasonal response, biological clock, brain, neuronal activity, gene manipulation