Research Note

The effect of photoperiod on the termination of the behavioral diapause of *Ixodes nipponensis* adults (Acari: Ixodidae)

Kazuyoshi FUJIMOTO

Department of Allergy and Immunology, Saitama Medical School, Moroyama-machi,
Saitama, 350-0495 Japan

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Abstract: The effect of the photoperiod on the termination of the behavioral diapause of *Ixodes nipponensis* Kitaoka et Saito adults reared in a long-day photoperiod (16L–8D) from egg to adult ecdysis was examined in plastic cylinders which were placed outdoors. The vertical activity in a plastic cylinder of *I. nipponensis* adults which were kept in a long-day photoperiod (long-day group) after they had molted (July 2000) was not found from November 2000 to mid-March 2001. However, the activity of *I. nipponensis* adults kept in a medium-day photoperiod (12L–12D) for about two months after molting (medium-day group) commenced in November 2000. These results suggest that the behavioral diapause of *I. nipponensis* adults is terminated by exposure to a medium-day photoperiod. Thus, the medium days of autumn appear to be important to the termination of the behavioral diapause of *I. nipponensis* adults.

INTRODUCTION

Ixodes nipponensis Kitaoka et Saito adults immediately entered behavioral diapause after they had molted (summer), and its termination began about four months later (autumn) (Fujimoto, 1996). However, the way in which the behavioral diapause terminates is unknown. According to Belozеров (1982), day length is important to the termination of the diapause in ticks. This may suggest that the medium or short days of autumn play an important role for the termination of the behavioral diapause of *I. nipponensis* adults, because their behavioral diapause begins to terminate in autumn (Fujimoto, 1996). In this study, *I. nipponensis* adults were kept in long-day (16L–8D) and medium-day (12L–12D) photoperiods after they had molted, and then their vertical

activities were observed in plastic cylinders placed outdoors. The objective of this study is to clarify whether or not the behavioral diapause of *I. nipponensis* adults is terminated by exposure to a medium-day photoperiod.

MATERIALS AND METHODS

Ticks

Ixodes nipponensis ticks were derived from adults collected by the flagging method in a hilly region of Saitama Prefecture. The adults collected fed on the ears of domestic rabbits, and the larvae and nymphs fed on albino mice in the laboratory, maintained at 24°C, with a 16L–8D photoperiod. The detached engorged ticks were placed in tick containers (Petri dishes 3–4.5 cm in diameter) with wet filter paper at the bottom, and kept in the same laboratory as above. The adults that

molted from the detached engorged nymphs were used in this study.

Adult activity in plastic cylinders

In order to confirm the termination of the behavioral diapause of adults, their activities were observed in plastic cylinders (see Fujimoto, 1996). Observations were made in an 8-month period from November 2000 to June 2001, using the same methods as in the previous report (Fujimoto, 1996). The plastic cylinders were placed outdoors (Saitama Medical School campus) where the adults were not directly exposed to sunlight or rain. Fifteen adults (9 females and 6 males) were released on bog moss in each cylinder. The adults released were divided into two groups. The adults of one group (long-day group) were kept in the laboratory (24°C,

16L–8D photoperiod) from July to November after they had molted (July 2000) and then transferred into a plastic cylinder (November 14, 2000). The adults of the other group (medium-day group) were kept in the laboratory from July to September after molting and then transferred into an incubator, maintained at 24°C with a 12L–12D photoperiod (September 13, 2000). The transferred adults were kept in the incubator from September to November and then transferred into a plastic cylinder (November 14, 2000). To keep the bog moss in the plastic cylinders wet, water was added to the black soil in the flower pots at appropriate intervals. The adults which were attached to the nylon cloth or internal walls of the plastic cylinders were counted daily as active ticks, and the percentage of active ticks was

Fig. 1. The vertical activities in plastic cylinders of *I. nipponensis* adults kept in long-day (long-day group) and medium-day (medium-day group) photoperiods after molting.

The adults of the long-day group (○) were kept in the laboratory (24°C, 16L–8D) from July to November after they had molted (July 2000) and then transferred into a plastic cylinder (November 14, 2000). The adults of the medium-day group (●) were kept in the laboratory from July to September after molting and then transferred into an incubator, maintained at 24°C, with a 12L–12D photoperiod (September 13). The adults transferred were kept in the incubator from September to November and then transferred into a plastic cylinder (November 14).

then calculated.

RESULTS AND DISCUSSION

Figure 1 shows the vertical activities in plastic cylinders of *I. nipponensis* adults exposed to long-day (long-day group) and medium-day (medium-day group) photoperiods after molting. No activity from the adults in the long-day group was found from November 2000 to mid-March 2001. However, the activity of the adults in the medium-day group was found from November, 2000. These results suggest that the termination of the behavioral diapause in the medium-day group begins in late autumn, but not in the long-day group. The activity of the medium-day group was low in winter. A similar activity was also found in the outdoor group which was placed outdoors after molting (Fujimoto, 2002). It is probable that this low activity is mainly due to the low winter temperatures. On the other hand, the adults in the long-day group began to climb the plastic cylinder from late March 2001 and then showed high activity from April to June. This suggests that the termination of the behavioral diapause in the long-day group begins the following spring. However, the behavioral diapause of *I. nipponensis* adults is not terminated by the exposure to a long-day photoperiod (Fujimoto, 2002). This termination in the long-day group may be due to the exposure of short or medium days (from about 10 to 12 hr of light per day) in the outdoors.

According to Belozеров (1982), the reaction of ticks to day length is divided into two basic categories; long-day reaction and short-day reaction. The termination of diapause in the long-day reaction type occurs in response to long days, while that of the short-day reaction type is in response to short days. In this study, the termination of the behavioral diapause of *I. nipponensis* adults occurred in response to a medium-day photoperiod. In addition, their behavioral diapause was not terminated by the exposure to a long-day photoperiod (Fujimoto, 2002). Judging from these results, *I. nipponensis* adults appear to be of the short-day reaction type.

In conclusion, the behavioral diapause of *I. nipponensis* adults is terminated by exposure to a medium-day photoperiod. Thus, the medium days of autumn appear to play an important role for the termination of the behavioral diapause of *I. nipponensis* adults.

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