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Regulatory roles of long non-coding RNAs relevant to antioxidant enzymes and immune responses of Apis cerana larvae following Ascosphaera apis invasion

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Long non-coding RNAs (lncRNAs) play an essential part in controlling gene expression and a variety of biological processes. However, whether and how lncRNAs regulate responses of Apis cerana larvae to Ascosphaera apis invasion has remained unclear until now. Here, the identification and analysis of lncRNAs in the guts ofA. cerana worker larvae were conducted. In total, 76 sense lncRNAs, 836 antisense lncRNAs, 184 intron lncRNAs, 362 bidirectional lncRNAs, and 2181 intron lncRNAs were discovered in the larval guts. Additionally, 30 known and 9 novel lncRNAs were potential precursors for 36 and 11 miRNAs, respectively. In the three comparison groups, 386, 351, and 272 DElncRNAs were respectively identified, indicating the change in the overall expression pattern of host lncRNAs following the A. apis invasion. Analysis of cis-acting effect showed that DElncRNAs in the 4-, 5-, and 6-day-old comparison groups putatively regulated 55, 30, and 20 up- and downstream genes, respectively, which were involved in a series of crucial functional terms and pathways, such as MAPK signaling pathway, and cell process. Analysis showed that 31, 8, and 11 DElncRNAs as potential antisense lncRNAs may interact with 26, 8, and 9 sense-strand mRNAs. Moreover, investigation of the competing endogenous RNA (ceRNA) network indicated that 148, 283, and 257 DElncRNAs were putatively regulated. The expression of target genes by targeting corresponding DEmiRNAs included those associated with antioxidant enzymes and immune responses. These results suggested that DElncRNAs played a potential part in the larval guts responding to the A. apis infection through a cis-acting manner and ceRNA mechanisms. Our findings deepen our understanding of interactions between A. cerana larvae and A. apis and offer a basis for clarifying the DElncRNA-mediated mechanisms underlying the host response to fungal invasion.