Developmental stage variation in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) low temperature tolerance: implications for overwintering

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Abstract

The fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is a very destructive polyphagous insect pest of cereal crops accounting for up to 100% yield losses. To survive winter low temperatures in the Americas, adults FAW are known to migrate south for warmer climates and then re-invade northern USA and Canada the following summer. Since its African invasion, no studies have looked at its overwintering biology. Specifically, there is no information on *in situ* ontogenetic low temperature tolerance, despite its significance in explaining overwintering survival. Here, we thus investigated low temperature tolerance of FAW larvae (3rd, 4th, 5th and 6th) and adults from field populations through assessing basal stress tolerance (critical thermal minima [CT_{min}], supercooling point [SCP] and chill coma recovery time [CCRT]) and plasticity using standardized protocols. Our results showed significant life stage effects on low temperature tolerance, although all were chill-susceptible. Adults had lower CT_{min} and CCRT than larvae (higher cold tolerance). However, early instar larvae had significantly depressed SCPs than later instars and adults. All larval instars tested showed no plastic responses to CT_{min}, while for adults, cold hardening appeared to come at a cost of CT_{min}. These results suggest ontogenetic differences in *S. frugiperda* cold hardiness albeit all are susceptible to chilling. Second, the absence or cost of hardening confirms FAW's maladaptation to low temperatures. However, Botswana microclimate records show that severe low temperature stress is limited, and thus, *in situ* overwintering is possible. These results are important in developing informed pest management options for effective management of FAW in Africa.