The oxygen consumption rate of three lepidopteran maize pest species measured by a Clark polarographic oxygen electrode using an air-to-water respirometer chamber of novel design

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In the past, traditional oxygen consumption measurements on air-breathers have been made by means of chemical (Winkler titration) (Winkler 1888), physical (Cartesian divers) (Howard et al. 1965) and manometric analyses (Van Slyke & Neil 1924). However, high demand for continuous monitoring, large numbers of required samples over a short period and non-invasive measurements of O₂ in complex biological samples have led to the development of a spectrum of O₂ detection techniques. These included low-cost electrochemical sensors such as the Clark polarographic O₂ electrode (Clark et al. 1953) and highly expensive opto-chemical sensors and biosensors (Peterson et al. 1984) and zirconium sensor technology which have already become indispensable in many laboratory applications.

The Clark polarographic oxygen electrode was designed for measuring oxygen concentration in water, for use with water-breathing organisms (Clark et al. 1953). The research reported here was aimed at developing a simple, affordable oxygen consumption measurement apparatus. Specific aims of this study were: 1) to modify the water-based respiration chamber used with the Clark polarographic oxygen electrode from Strathkelvin Instruments to measure O₂ consumption of air-breathers. An air-to-water respirometer was therefore designed, 2) to validate the O₂ consumption rate (OCR) determined by the air-to-water respirometer, through comparison between OCR measurements of the air-to-water respirometer and the reliable Scholander manometric respirometer, and 3) to measure and compare the OCR of three lepidopteran species that are pests of maize in South Africa, viz. larvae of two stem borer species, Busseola fusca (Fuller) (Noctuidae) and Chilo partellus (Swinhoe) (Pyralidae) as well as the fall armyworm, Spodoptera frugiperda (J.E. Smith) (Noctuidae), a leaf feeding pest with the air-to-water respirometer.

Stem borer larvae were collected during March 2016 from maize ears and stems in a field near Potchefstroom (26°46’S 27°08’E), North-West Province, South Africa. The larvae were reared in plastic containers (40 × 20 × 15 cm) with aerated lids. Pieces of stems of conventional non-Bt maize were provided as food at 4-day intervals. The larvae were kept in a rearing room at 26 ± 1 °C, with 60 ± 10 % relative humidity and 14L:10D photoperiod until pupation. Male and female moths emerging from the pupae were confined to oviposition chambers following the technique described by Kruger et al. (2012) for B. fusca. Eggs were removed from maize stems and kept in the same rearing room described above until larvae hatched. Neonate larvae were transferred onto pieces of maize stem with the whorl still intact and reared in plastic containers. Five groups with four larvae per group of sixth instar larvae were then used for the OCR experiments.

Spodoptera frugiperda larvae were collected from a maize field at Brits (25°23’S 27°34’E). These larvae were kept individually in plastic containers (40 × 20 × 15 cm) with aerated lids. Stem pieces and leaf material, cut from beneath the whorl of conventional non-Bt maize plants were provided as food at 4-day intervals. These larvae were also kept in a rearing room under conditions as described above. The oxygen consumption rate of sixth instar larvae of two stem borer species, Busseola fusca (Fuller) (Noctuidae) and Chilo partellus (Swinhoe) (Pyralidae) as well as the fall armyworm, Spodoptera frugiperda (J.E. Smith) (Noctuidae), a leaf feeding pest with the air-to-water respirometer.