sons. First, the antisense sequence expressed in the transformed cell is unstable. Second, the instability of the antisense sequence expressed in the transformed cell concomitantly creates difficulty in delivery of the sequence to a host, cell type, or biological system remote from the transgenic cell. Third, the difficulties encountered with instability and delivery of the antisense sequence create difficulties in attempting to provide a dose within the recombinant cell expressing the antisense sequence that can effectively modulate the level of expression of the target sense nucleotide sequence.

**[0008]** There have been few improvements in technologies for modulating the level of gene expression within a cell, tissue, or organism, and in particular, a lack of developed technologies for delaying, repressing or otherwise reducing the expression of specific genes using recombinant DNA technology. Furthermore, as a consequence of the unpredictability of these approaches, no commercially viable means for modulating the level of expression of a specific gene in a eukaryotic or prokaryotic organism is available.

**[0009]** Double stranded RNA mediated inhibition of specific genes in various pests has been previously demonstrated. dsRNA mediated approaches to genetic control have been tested in the fruit fly *Drosophila melanogaster* (Tabara et al., 1998, Science 282:430-431). Tabara et. al. describe a method for delivery of dsRNA involved generating transgenic insects that express double stranded RNA molecules or injecting dsRNA solutions into the insect body or within the egg sac prior to or during embryonic development. Research investigators have previously demonstrated that double stranded RNA mediated gene suppression can be achieved in nematodes either by feeding or by soaking the nematodes in solutions containing double stranded or small interfering RNA molecules and by injection of the dsRNA molecules. Rajagopal et. al. described failed attempts to suppress an endogenous gene in larvae of the insect pest *Spodoptera litura* by feeding or by soaking neonate larvae in solutions containing dsRNA specific for the target gene, but was successful in suppression after larvae were injected with dsRNA into the hemolymph of $5^{th}$ instar larvae using a microapplicator (J. Biol. Chem., 2002, 277:46849-46851). Similarly, Mesa et al. (US 2003/0150017) prophetically described a preferred locus for inhibition of the lepidopteran larvae *Helicoverpa armigera* using dsRNA delivered to the larvae by ingestion of a plant transformed to produce the dsRNA. It is believed that it would be impractical to provide dsRNA molecules in the diet of most invertebrate pest species or to inject compositions containing dsRNA into the bodies of invertebrate pests. The diet method of providing dsRNA molecules to invertebrate pests is impractical because RNA molecules, even stabilized double stranded RNA molecules, are in effect highly unstable in mildly alkaline or acidic environments such as those found in the digestive tracts of most invertebrate pests, and easily degraded by nucleases in the environment. Therefore, there exists a need for improved methods of modulating gene expression by repressing, delaying or otherwise reducing gene expression within a particular invertebrate pest for the purpose of controlling pest infestation or to introduce novel phenotypic traits.

## SUMMARY OF THE INVENTION

**[0010]** The present invention, in one embodiment, comprises a method of inhibiting expression of a target gene in an invertebrate pest. Specifically, the present invention comprises a method of modulating or inhibiting expression of one or more target genes in an invertebrate pest, in particular, in Western corn rootworm (WCR, *Diabrotica virgifera virgifera* LeConte) and the like, that cause cessation of feeding, growth, development, reproduction and infectivity and eventually result in the death of the insect. The method comprises introduction of partial or fully, stabilized double-stranded RNA (dsRNA) or its modified forms such as small interfering RNA (siRNA) sequences, into the cells or into the extracellular environment, such as the midgut, within an invertebrate pest body wherein the dsRNA or siRNA enters the cells and inhibits expression of at least one or more target genes and wherein inhibition of the one or more target genes exerts a deleterious effect upon the invertebrate pest. It is specifically contemplated that the methods and compositions of the present invention will be useful in limiting or eliminating invertebrate pest infestation in or on any pest host, pest symbiont, or environment in which a pest prefers by providing one or more compositions comprising dsRNA molecules in the diet of the pest so long as the pest digestive system pH is within the range of from about 4.5 to about 9.5, from about 5 to about 9, from about 6 to about 8, and from about pH 7.0.

**[0011]** The present application discloses an exemplary sequence listing containing the both the nucleotide and amino acid sequences from Western Corn Rootworm (WCR, *Diabrotica virgifera*), as set forth in SEQ ID NO:1 through SEQ ID NO:143 and SEQ ID NO:169 through SEQ ID NO:174 and from other coleopteran insects including Colorado Potato Beetle (CPB, *Leptinotarsa decemlineata*) and Red Flour Beetle (RFB, *Tribolium castaneum*), from lepidopteran insects including European Corn Borer (ECB, *Ostrinia nubilalis*), Black Cutworm (BCW, *Agrotis ipsilon*), Corn Earworm (CEW, *Helicoverpa zea*), Fall Army worm (FAW, *Spodoptera frugiperda*), Cotton Ball Weevil (BWV, *Anthonomus grandis*), silkworms (*Bombyx mori*) and *Manduca sexta* and from Dipteran insects including *Drosophila melanogaster, Anopheles gambiae*, and *Aedes aegypti*, as set forth in SEQ ID NO:144 through SEQ ID NO:159. The sequence listing is included along with the paper copy of this application on one CD-ROM diskette.

**[0012]** The computer readable form at file corresponding to the sequence listing contains the sequence listing information for corn rootworm Unigene sequences, EST sequences, corn rootworm specific probe sequences, primer sequences, amplicon sequences, and sequences encoding double stranded RNA sequences and the v-ATPase and ribosomal protein L19 orthologs from other insects as described above (SEQ ID NO:144 through SEQ ID NO:159).

**[0013]** The present invention provides a method for suppression of gene expression in an invertebrate pest such as a corn rootworm or related species comprises the step of providing in the diet of the pest a gene suppressive amount of at least one dsRNA molecule transcribed from a nucleotide sequence as set forth in, SEQ ID NO:1 through SEQ ID NO:143 and SEQ ID NO:169 through SEQ ID NO:174 in the sequence listing, at least one segment of which is complementary to an mRNA sequence formed within the cells of the pest, and observing the death, inhibition, stunting, or cessation of feeding of the pest.

**[0014]** In another aspect of the present invention, the method comprises the step of feeding to the pest one (or more) stabilized dsRNA molecules or its modified form such as an siRNA molecule the nucleotide sequence of which is at least from about 80, 81, 82, 83, 84, 85, 86, 87, 88 89, 90, 91, 92, 93,