Contents lists available at SciVerse ScienceDirect

Gene

journal homepage: www.elsevier.com/locate/gene

Characterization of the complete mitochondrial genome of *Diaphania pyloalis* (Lepidoptera: Pyralididae)

Bao-Jian Zhu $^1\!,$ Qiu-Ning Liu $^1\!,$ Li-Shang Dai, Lei Wang, Yu Sun, Kun-Zhang Lin, Guo-Qing Wei, Chao-Liang Liu *

College of Life Science, Anhui Agricultural University, 130 Changjiang West Road, 230036, PR China

ARTICLE INFO

Article history: Accepted 15 June 2013 Available online 26 June 2013

Keywords: Mitochondrial genome Lepidoptera Diaphania pyloalis Phylogeny

ABSTRACT

The complete mitochondrial genome (mitogenome) of *Diaphania pyloalis* (Lepidoptera: Pyralididae) was determined to be 15,298 bp and has the typical gene organization of mitogenomes from lepidopteran insects. It consists of 13 protein-coding genes (PCGs), two rRNA genes, 22 tRNA genes and an A + T-rich region. The A + T content of this mitogenome is 80.83% and the AT skew is slightly positive. All PCGs are initiated by ATN codons, except for cytochrome c oxidase subunit 1 (*cox1*) gene which is initiated by CGA. Only the *cox2* gene has an incomplete stop codon consisting of just a T. All the tRNA genes display a typical clover-leaf structure of mitochondrial tRNA. The A + T-rich region of the mitogenome is 332 bp in length, including several common features found in lepidopteran mitogenomes. Phylogenetic analysis showed that the *D. pyloalis* is close to Pyralididae.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

The mitochondrial genome (mitogenome) forms a unit of genetic information and evolves independently from the nuclear genome. Mitochondrial DNA has been widely used for diverse evolutionary studies (Wolstenholme, 1992). Insect mitogenome DNA (mtDNA) is a circular molecule containing 13 protein coding genes (PCGs), subunits 6 and 8 of the ATPase (*atp6* and *atp8*), cytochrome B (*cob*), cytochrome c oxidase subunits 1–3 (*cox1–cox3*), NADH dehydrogenase subunits 1–6 and 4L (*nad1-6* and *nad4L*), two ribosomal RNA genes encoding the small and large subunit rRNAs (*rrnL* and *rrnS*), 22 transfer RNA (tRNA) genes and a A + T-rich region (Boore, 1999; Moritz et al., 1987; Wolstenholme, 1992).

Up to now, only a few lepidopteran mitogenomes are available from species in the Bombycoidea, Geometroidea, Noctuoidea, Pyraloidea, Papilionoidea and Tortricoidea (Table 1). The complete or partial mitogenomes of six species of Pyraloidea had been sequenced: *Cnaphalocrocis medinalis* (Chai et al., 2012), *Chilo suppressalis* (Yin et al., 2011), *Ostrinia furnacalis* (Coates et al., 2005), *Ostrinia nubilalis* (Coates et al., 2005), *Maruca vitrata* (Margam et al., 2011) and *Diatraea saccharalis* (Li et al., 2011).

Diaphania pyloalis (Lepidoptera: Pyralididae), a member of wellknown mulberry pests, is widely distributed in the main mulberry-

* Corresponding author. Tel./fax: +86 551 5786201.

¹ These authors contributed equally to this work.

growing regions and causes serious mulberry leaves yield losses. In the present study, the complete mitogenome of *D. pyloalis* was determined and the phylogenetic analyses to the selected species from Lepidoptera, Orthoptera and Diptera based on the mitogenome sequences were performed.

2. Materials and methods

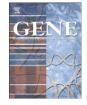
2.1. DNA extraction

The larvae of *D. pyloalis* were collected from mulberry garden in Hefei, Anhui Province. All larvae were fed with fresh mulberry leaves under normal conditions. Total DNA from the larvae was extracted with the Genomic DNA Extraction Kit (AxyPrep, USA) and used for PCR amplification of the complete mitogenome.

2.2. PCR amplification and sequencing

Nine primer pairs were designed for PCR according to the conserved nucleotide sequences of known mitochondrial sequences from Lepidoptera insects (Chai et al., 2012; Coates et al., 2005; Li et al., 2011; Margam et al., 2011; Yin et al., 2011) (Table 2). The fragments were amplified using Aidlab $2 \times$ PCR Master mix (Beijing, China) according to the manufacturer's instructions. The PCR was performed under the following conditions: 5 min at 94 °C, followed by 35 cycles of 35 s at 94 °C, 1–3 min at 50–60 °C, and 10 min at 72 °C. The PCR products were analyzed by agarose gel electrophoresis (1% w/v) and purified with a DNA gel extraction kit (AxyPrep, USA). The purified PCR products were ligated into the PMD-19 T vector







Abbreviations: PCR, polymerase chain reaction; ATPase, adenosine triphosphatase; NADH, nicotinamide adenine dinucleotide hydrogen.

E-mail address: cyschx@163.com (C.-L. Liu).

^{0378-1119/\$ -} see front matter © 2013 Elsevier B.V. All rights reserved. http://dx.doi.org/10.1016/j.gene.2013.06.035

Table 1

The complete and near-complete mitochondrial genome of lepidoptera.

| Diaphania pyloalis15, 298This studyCnaphalocrocis medinalis15, 388JN246082Chai et al. (2012)Chilo suppressalis15, 465HQ860290Yin et al. (2011)Ostrinia nubilalis14, 535NC_003367Coates et al. (2005)Ostrinia furnacalis14, 536AF467260Coates et al. (2005)Maruca vitrata14, 054HM751150Margam et al. (2011)Diatraea saccharalis15, 490FJ240227Li et al. (2011)Bombyx mori15, 656AB070264Yukuhiro et al. (2002)Japanese15, 682AY301620Pan et al. (2008)Bombyx mandarina15, 575AY242996Liu et al. (2008)Antheraea pernyi15, 575AY242963Liu et al. (2008)Antheraea yamamai15, 338EU726630Kim et al. (2009)Samia cynthia ricini15, 366JN215366Kim et al. (2012)Actias selene15, 516EU286785Cameron and Whiting, (2008)Sphinx morio15, 299KC470083Kim et al. (2010)Helicoverpa armigera15, 481GU592049Liao et al. (2010)Helicoverpa armigera15, 456JX316220Wu et al. (2008)Sphinx morio15, 293AM946601Salvato et al. (2008)Sphinx morio15, 593AM946601Salvato e | Species | Length (bp) | Accession number | References |
|--|--------------------------|----------------|---------------------|-----------------------------|
| Chilo suppressalis15, 465HQ860290Yin et al. (2011)Ostrinia nubilalis14, 535NC_003367Coates et al. (2005)Ostrinia furnacalis14, 536AF467260Coates et al. (2005)Maruca vitrata14, 054HM751150Margam et al. (2011)Diatraea saccharalis15, 490FJ240227Li et al. (2011)Bombyx mori15, 656AB070264Yukuhiro et al. (2002)Japanese15, 928NC_003395Yukuhiro et al. (2002)Bombyx mandarinaAntheraea pernyi15, 575AY242996Chinese15, 682AY301620Pan et al. (2008)Bombyx mandarina5, 575AY242966Liu et al. (2008)Antheraea pernyi15, 575AY242966Kim et al. (2008)Eriogyna pyretorum15, 327FJ685653Jiang et al. (2009)Samia cynthia ricini15, 366JN215366Kim et al. (2012)Actias selene15, 236JX186589Liu et al. (2012)Caligula boisduvalii15, 516EU286785Cameron and Whiting, (2008)Manduca sexta15, 516EU286785Cameron and Whiting, (2008)Sphinx morio15, 299KC470083Kim et al. (2010)Helicoverpa armigera15, 347GU188273Yin et al. (2010)Spodoptera exigua15, 680DQ073916Lao et al. (2008)Advaophyes honmai15, 680DQ073916Lee et al. (2008)Advaophyes honmai15, 680DQ073916Lee et al. (2006)Grapholita molesta15, 776 <td< td=""><td>Diaphania pyloalis</td><td>15, 298</td><td></td><td>This study</td></td<> | Diaphania pyloalis | 15, 298 | | This study |
| Ostrinia nubilalis14, 535 14, 536NC_003367 Coates et al. (2005)Ostrinia furnacalis14, 536AF467260 AF467260Coates et al. (2005)Maruca vitrata14, 054HM751150Margam et al. (2011)Diatraea saccharalis15, 490FJ240227Li et al. (2011)Bombyx mori15, 656AB070264Yukuhiro et al. (2002)Japanese15, 928NC_003395Yukuhiro et al. (2002)Bombyx mandarinaAntheraea permyi15, 575AY242996Chinese15, 682AY301620Pan et al. (2008)Bombyx mandarinaInteraea paramai15, 338EU726630Antheraea paramani15, 337FJ685653Jiang et al. (2009)Samia cynthia ricini15, 366JN215366Kim et al. (2012)Actias selene15, 236JX186589Liu et al. (2012)Caligula boisduvalii15, 360NC_010613Hong et al. (2008)Sphinx morio15, 299KC470083Kim et al. (2010)Hyphantria cunea15, 441GU592049Liao et al. (2010)Spodoptera exigua15, 456JX316220Wu et al. (2013)Cydia pomonella15, 253JX407107Shi et al. (2008)Adxophyes honmai15, 680DQ073916Lee et al. (2008)Adoxophyes honmai15, 680DQ073916Lee et al. (2006)Grapholita molesta15, 776HQ116416Gong et al. (2011)Adoxophyes honmai15, 688HM204705Zhao et al. (2009)Coreana raphaelis15, 3 | Cnaphalocrocis medinalis | 15, 388 | JN246082 | Chai et al. (2012) |
| Ostrinia furnacalis 14, 536 AF467260 Coates et al. (2005) Maruca vitrata 14, 054 HM751150 Margam et al. (2011) Diatraea saccharalis 15, 490 FJ240227 Li et al. (2011) Bombyx mori 15, 656 AB070264 Yukuhiro et al. (2002) Japanese 15, 928 NC_003395 Yukuhiro et al. (2002) Bombyx mandarina Theraea pernyi 15, 575 AY242996 Liu et al. (2008) Bombyx mandarina Theraea parmyi 15, 575 AY242996 Liu et al. (2008) Antheraea parmyi 15, 575 AY242996 Liu et al. (2008) Eriogyna pyretorum 15, 327 FJ685653 Jiang et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2010) Sphinx morio 15, 247 GU188273 Yin et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2010) <t< td=""><td>Chilo suppressalis</td><td>15, 465</td><td>HQ860290</td><td>Yin et al. (2011)</td></t<> | Chilo suppressalis | 15, 465 | HQ860290 | Yin et al. (2011) |
| Maruca vitrata14, 054HM751150Margam et al. (2011)Diatraea saccharalis15, 490FJ240227Li et al. (2011)Bombyx mori15, 656AB070264Yukuhiro et al. (2002)Japanese15, 928NC_003395Yukuhiro et al. (2002)Bombyx mandarina15, 682AY301620Pan et al. (2008)Chinese15, 575AY242996Liu et al. (2008)Bombyx mandarina15, 575AY242996Liu et al. (2008)Antheraea pernyi15, 575AY242996Liu et al. (2008)Bombyx mandarina15, 338EU726630Kim et al. (2008)Antheraea yamanai15, 366JN215366Kim et al. (2012)Actias selene15, 236JX186589Liu et al. (2012)Actias selene15, 360NC_010613Hong et al. (2008)Sphinx morio15, 299KC470083Kim et al. (1n press)Hyphantria cunea15, 441GU188273Vin et al. (2010)Spodoptera exigua15, 456JX316220Wu et al. (2010)Spodoptera exigua15, 456JX316220Wu et al. (2013)Cydia pomonella15, 253JK407107Shi et al. (2008)Phthonandria atrilineata15, 680DQ073916Lee et al. (2008)Adoxophyes honmai15, 686HM204705Zhao et al. (2001)Arbegeia melete15, 140EU597124Hong et al. (2009)Coreana raphaelis15, 314NC_007976Kim et al. (2006)Acraea issoria15, 245GQ376195Hu et al. (2011) <td>Ostrinia nubilalis</td> <td>14, 535</td> <td>NC_003367</td> <td>Coates et al. (2005)</td> | Ostrinia nubilalis | 14, 535 | NC_003367 | Coates et al. (2005) |
| Diatrae saccharalis 15, 490 FJ240227 Li et al. (2011) Bombyx mori 15, 656 AB070264 Yukuhiro et al. (2002) Japanese 15, 928 NC_003395 Yukuhiro et al. (2002) Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea pernyi 15, 575 AY242963 Kim et al. (2008) Antheraea yamamai 15, 338 EU726630 Kim et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (in press) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 477 GU188273 Yin et al. (2013) <t< td=""><td>Ostrinia furnacalis</td><td>14, 536</td><td>AF467260</td><td>Coates et al. (2005)</td></t<> | Ostrinia furnacalis | 14, 536 | AF467260 | Coates et al. (2005) |
| Bombyx mori 15, 656 AB070264 Yukuhiro et al. (2002) Japanese 15, 928 NC_003395 Yukuhiro et al. (2002) Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina 15, 575 AY242996 Liu et al. (2008) Antheraea pernyi 15, 575 AY242966 Liu et al. (2008) Antheraea yamamai 15, 338 EU726630 Kim et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 616 EU286785 Cameron and Whiting, (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Ochrogaster lunifer 15, 593 < | Maruca vitrata | 14, 054 | HM751150 | Margam et al. (2011) |
| Japanese 15, 928 NC_003395 Yukuhiro et al. (2002) Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina 15, 575 AY242996 Liu et al. (2008) Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea paramai 15, 575 AY242966 Kim et al. (2008) Eriogyna pyretorum 15, 327 FJ685653 Jiang et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 616 EU286785 Cameron and Whiting, (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Hylantria cunea 15, 481 GU592049 Liao et al. (2010) Hylonatria cunea 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 776 HQ116416 Gong et al. (2008) Grapholita molesta | Diatraea saccharalis | 15, 490 | FJ240227 | Li et al. (2011) |
| Bombyx mandarina 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina 15, 575 AY242996 Liu et al. (2008) Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea paramai 15, 375 AY242996 Liu et al. (2008) Antheraea yamamai 15, 375 AY242996 Liu et al. (2008) Antheraea yamamai 15, 375 AY242996 Liu et al. (2008) Samia cynthia ricini 15, 326 JX186589 Liu et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Sphinx morio 15, 481 GU592049 Liao et al. (2010) Hyphantria cunea 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ0 | Bombyx mori | 15, 656 | AB070264 | Yukuhiro et al. (2002) |
| Chinese 15, 682 AY301620 Pan et al. (2008) Bombyx mandarina Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea parmyi 15, 575 AY242996 Liu et al. (2008) Eriogyna pyretorum 15, 338 EU726630 Kim et al. (2008) Eriogyna pyretorum 15, 327 FJ685653 Jiang et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JK407107 Shi et al. (2013) Ochrogaster lunifer 15, 680 DQ073916 Lee et al. (2008) Adaxophyse honmai <t< td=""><td>Japanese</td><td>15, 928</td><td>NC_003395</td><td>Yukuhiro et al. (2002)</td></t<> | Japanese | 15, 928 | NC_003395 | Yukuhiro et al. (2002) |
| Bombyx mandarina Intervention Intervention Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea yamamai 15, 338 EU726630 Kim et al. (2008) Eriogyna pyretorum 15, 327 FJ685653 Jiang et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Helicoverpa armigera 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 453 JX16220 Wu et al. (2013) Cydia pomonella 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2001) Grapholita molesta 15, 776 HQ11641 | Bombyx mandarina | | | |
| Antheraea pernyi 15, 575 AY242996 Liu et al. (2008) Antheraea yamamai 15, 338 EU726630 Kim et al. (2008) Eriogyna pyretorum 15, 327 FJ685653 Jiang et al. (2009) Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Helicoverpa armigera 15, 481 GU592049 Liao et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Ardozeia | Chinese | 15, 682 | AY301620 | Pan et al. (2008) |
| Antheraea yamamai15, 338EU726630Kim et al. (2008)Eriogyna pyretorum15, 327FJ685653Jiang et al. (2009)Samia cynthia ricini15, 366JN215366Kim et al. (2012)Actias selene15, 236JX186589Liu et al. (2012)Caligula boisduvalii15, 360NC_010613Hong et al. (2008)Manduca sexta15, 516EU286785Cameron and Whiting, (2008)Sphinx morio15, 299KC470083Kim et al. (2010)Helicoverpa armigera15, 481GU592049Liao et al. (2010)Helicoverpa armigera15, 456JX316220Wu et al. (2013)Cydia pomonella15, 593AM946601Salvato et al. (2008)Phthonandria atrilineata15, 499EU569764Yang et al. (2008)Adoxophyes honmai15, 680DQ073916Lee et al. (2006)Grapholita molesta15, 776HQ116416Gong et al. (2011)Spilonota lechriaspis15, 314NC_007976Kim et al. (2009)Coreana raphaelis15, 140EU597124Hong et al. (2009)Coreana raphaelis15, 140JF504707Kim et al. (2010)Fabriciana nerippe15, 140JF504707Kim et al. (2011)Kalima inachus15, 183JN857943Qin et al. (2012) | Bombyx mandarina | | | |
| Eriogyna pyretorum15, 327FJ685653Jiang et al. (2009)Samia cynthia ricini15, 366JN215366Kim et al. (2012)Actias selene15, 236JX186589Liu et al. (2012)Caligula boisduvalii15, 360NC_010613Hong et al. (2008)Manduca sexta15, 516EU286785Cameron and Whiting, (2008)Sphinx morio15, 299KC470083Kim et al. (2010)Hyphantria cunea15, 481GU592049Liao et al. (2010)Helicoverpa armigera15, 477GU188273Yin et al. (2013)Spodoptera exigua15, 456JX316220Wu et al. (2013)Ochrogaster lunifer15, 593AM946601Salvato et al. (2008)Phthonandria atrilineata15, 776HQ116416Gong et al. (2008)Adoxophyes honmai15, 680DQ073916Lee et al. (2011)Spilonota lechriaspis15, 314NC_007976Kim et al. (2010)Artogeia melete15, 140EU597124Hong et al. (2009)Coreana raphaelis15, 245GQ376195Hu et al. (2006)Acarae issoria15, 245GQ376195Hu et al. (2010)Fabriciana nerippe15, 140JF504707Kim et al. (2011)Kalima inachus15, 183JN857943Qin et al. (2012) | Antheraea pernyi | 15, 575 | AY242996 | Liu et al. (2008) |
| Samia cynthia ricini 15, 366 JN215366 Kim et al. (2012) Actias selene 15, 236 JX186589 Liu et al. (2012) Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (2010) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JX407107 Shi et al. (2013) Cydia pomonella 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2010) Acraea issoria 15, 245 | Antheraea yamamai | 15, 338 | EU726630 | Kim et al. (2008) |
| Actias selene15, 236JX186589Liu et al. (2012)Caligula boisduvalii15, 360NC_010613Hong et al. (2008)Manduca sexta15, 516EU286785Cameron and Whiting, (2008)Sphinx morio15, 299KC470083Kim et al. (in press)Hyphantria cunea15, 441GU582049Liao et al. (2010)Spodoptera exigua15, 456JX316220Wu et al. (2013)Cydia pomonella15, 253JX407107Shi et al. (2013)Ochrogaster lunifer15, 693AM946601Salvato et al. (2008)Phthonandria atrilineata15, 680DQ073916Lee et al. (2008)Grapholita molesta15, 776HQ116416Gong et al. (2011)Spilonota lechriaspis15, 314NC_007976Kim et al. (2009)Coreana raphaelis15, 140EU597124Hong et al. (2006)Acraea issoria15, 245GQ376195Hu et al. (2010)Fabriciana nerippe15, 140JF504707Kim et al. (2011)Kallima inachus15, 183JN857943Qin et al. (2012) | Eriogyna pyretorum | 15, 327 | FJ685653 | Jiang et al. (2009) |
| Caligula boisduvalii 15, 360 NC_010613 Hong et al. (2008) Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (in press) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JX407107 Shi et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Phthonandria atrilineata 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2006) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 G0376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kalima inachus 15, 183 JN857943 Qin et al. (2012) | Samia cynthia ricini | 15, 366 | JN215366 | Kim et al. (2012) |
| Manduca sexta 15, 516 EU286785 Cameron and Whiting, (2008) Sphinx morio 15, 299 KC470083 Kim et al. (in press) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 481 GU592049 Liao et al. (2010) Spodoptera exigua 15, 456 JX31620 Wu et al. (2013) Cydia pomonella 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 348 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kalima inachus 15, 183 JN857943 Qin et al. (2012) | Actias selene | 15, 236 | JX186589 | Liu et al. (2012) |
| Sphinx morio 15, 299 KC470083 Kim et al. (in press) Hyphantria cunea 15, 481 GU592049 Liao et al. (2010) Helicoverpa armigera 15, 481 GU188273 Yin et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JX407107 Shi et al. (2008) Ochrogaster lunifer 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 699 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 140 Rim et al. (2010) Acraea issoria Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kalima inachus 15, 183 JN857943 Qin et al. (2012) | Caligula boisduvalii | 15, 360 | NC_010613 | Hong et al. (2008) |
| Hyphantria cunea15, 481GU592049Liao et al. (2010)Helicoverpa armigera15, 347GU188273Yin et al. (2010)Spodoptera exigua15, 456JX316220Wu et al. (2013)Cydia pomonella15, 253JX407107Shi et al. (2013)Ochrogaster lunifer15, 593AM946601Salvato et al. (2008)Phthonandria atrilineata15, 499EU569764Yang et al. (2008)Adoxophyes honmai15, 680DQ073916Lee et al. (2006)Grapholita molesta15, 776HQ116416Gong et al. (2011)Spilonota lechriaspis15, 368HM204705Zhao et al. (2009)Coreana raphaelis15, 140EU597124Hong et al. (2006)Acraea issoria15, 245GQ376195Hu et al. (2010)Fabriciana nerippe15, 140JF504707Kim et al. (2011)Kallima inachus15, 183JN857943Qin et al. (2012) | Manduca sexta | 15, 516 | EU286785 | Cameron and Whiting, (2008) |
| Helicoverpa armigera 15, 347 GU188273 Yin et al. (2010) Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JX407107 Shi et al. (2013) Ochrogaster lunifer 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 348 HM204705 Zhao et al. (2009) Coreana raphaelis 15, 140 EU597124 Hong et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2006) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2010) Kalima inachus 15, 183 JN857943 Qin et al. (2011) | Sphinx morio | 15, 299 | KC470083 | Kim et al. (in press) |
| Spodoptera exigua 15, 456 JX316220 Wu et al. (2013) Cydia pomonella 15, 253 JX407107 Shi et al. (2013) Ochrogaster lunifer 15, 253 JX407107 Shi et al. (2013) Ochrogaster lunifer 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Hyphantria cunea | 15, 481 | GU592049 | Liao et al. (2010) |
| Cydia pomonella 15, 253 JX407107 Shi et al. (2013) Ochrogaster lunifer 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Helicoverpa armigera | 15, 347 | GU188273 | Yin et al. (2010) |
| Ochrogaster lunifer 15, 593 AM946601 Salvato et al. (2008) Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Spodoptera exigua | 15, 456 | JX316220 | Wu et al. (2013) |
| Phthonandria atrilineata 15, 499 EU569764 Yang et al. (2008) Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2006) Coreana raphaelis 15, 245 GQ376195 Hu et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Cydia pomonella | 15, 253 | JX407107 | Shi et al. (2013) |
| Adoxophyes honmai 15, 680 DQ073916 Lee et al. (2006) Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 183 JN857943 Qin et al. (2012) | Ochrogaster lunifer | 15, 593 | AM946601 | Salvato et al. (2008) |
| Grapholita molesta 15, 776 HQ116416 Gong et al. (2011) Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EUS97124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 183 JN857943 Qin et al. (2012) | Phthonandria atrilineata | 15, 499 | EU569764 | Yang et al. (2008) |
| Spilonota lechriaspis 15, 368 HM204705 Zhao et al. (2011) Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Adoxophyes honmai | 15, 680 | DQ073916 | Lee et al. (2006) |
| Artogeia melete 15, 140 EU597124 Hong et al. (2009) Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 183 JN857943 Qin et al. (2012) | Grapholita molesta | 15, 776 | HQ116416 | Gong et al. (2011) |
| Coreana raphaelis 15, 314 NC_007976 Kim et al. (2006) Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Spilonota lechriaspis | 15, 368 | HM204705 | Zhao et al. (2011) |
| Acraea issoria 15, 245 GQ376195 Hu et al. (2010) Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Artogeia melete | 15, 140 | EU597124 | Hong et al. (2009) |
| Fabriciana nerippe 15, 140 JF504707 Kim et al. (2011) Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Coreana raphaelis | 15, 314 | NC_007976 | Kim et al. (2006) |
| Kallima inachus 15, 183 JN857943 Qin et al. (2012) | Acraea issoria | 15, 245 | GQ376195 | Hu et al. (2010) |
| | Fabriciana nerippe | 15, 140 | JF504707 | Kim et al. (2011) |
| Sasakia charonda 15, 233 JX119051 Wang et al. (2012) | Kallima inachus | 15, 183 | JN857943 | Qin et al. (2012) |
| | Sasakia charonda | 15, 233 | JX119051 | Wang et al. (2012) |

(TaKaRa Co., Dalian, China) and sequenced at Invitrogen (Shanghai, China).

2.3. Sequence annotation

Sequence annotation was performed using the blast tools in NCBI web site (http://blast.ncbi.nlm.nih.gov/Blast) and DNAStar package (DNAStar Inc. Madison, USA). The nucleotide sequences of PCGs were translated with the invertebrate mitogenome genetic code and the PCGs were identified by sequence similarity with *C. suppressalis* (Yin et al., 2011). Identification of tRNA genes was verified using the

| Table | 2 |
|-------|---|
|-------|---|

| Primers used for amplificat | ion of the mitogenome | of D. pyloalis |
|-----------------------------|-----------------------|----------------|
|-----------------------------|-----------------------|----------------|

| Primer no. | Primer sequence $(5' \rightarrow 3')$ |
|------------|---------------------------------------|
| F1 | GCTTTTGGGCTCATACCTCA |
| R1 | GATGAAATACCTGCAAGATGAAG |
| F2 | TGGAGCAGGAACAGGATGAAC |
| R2 | GAGACCADTACTTGCTTTCAG |
| F3 | ATTTGTGGAGCTAATCATAG |
| R3 | GGTCAGGGACTATAATCTAC |
| F4 | TCGACCTGGAACTTTAGC |
| R4 | GCAGCTATAGCCGCTCCTACT |
| F5 | TAAAGCAGAAACAGGAGTAG |
| R5 | ATTGCGATATTATTTCTTTTG |
| F6 | ACATTCTTAGGTGGATTA |
| R6 | GTTAAAGTGGCATTATCT |
| F7 | GGAGCTTCTACATGAGCTTTTGG |
| R7 | GTTTGCGACCTCGATGTTG |
| F8 | GGTCCCTTACGAATTTGAATATATCCT |
| R8 | AAACTAGGATTAGATACCCTATTAT |
| F9 | CTCTACTTTGTTACGACTTATT |
| R9 | TCTAGGCCAATTCAACAACC |

tRNAscan-SE program. The potential stem-loop secondary structures within these tRNA gene sequences were calculated using the tRNAscan-SE Search Server (http://lowelab.ucsc.edu/tRNAscan-SE/) (Lowe and Eddy, 1997). The secondary structures of tRNA genes that could not be predicted using the tRNAscan-SE were analyzed by comparison with the nucleotide sequences of other insect tRNA sequences (Chai et al., 2012; Coates et al., 2005; Li et al., 2011; Margam et al., 2011; Yin et al., 2011). Composition skewness was calculated according to the formulas: AT skew = [A - T]/[A + T]; GC skew = [G - C]/[G + C] (Junqueira et al., 2004). Tandem repeats in the A + T-rich region were predicted using the Tandem Repeats Finder program (http://tandem.bu.edu/trf/trf.html) (Benson, 1999). Alignments of PCGs from various lepidopteran mitogenomes were performed using Clustal X (Thompson et al., 1997).

2.4. Phylogenetic analysis

The mitogenomes of 32 lepidopteran species (including Bombycoidea, Geometroidea, Noctuoidea, Pyraloidea, Tortricoidea and Papilionoidea) were obtained from the GenBank database (Table 1) and used for phylogenetic analysis. The mitogenomes of *Locusta migratoria* (NC_001712), *Drosophila yakuba* (NC_001322) and *Anopheles gambiae* (NC_002084) were used as outgroups (Beard et al., 1993; Clary and Wolstenholme, 1985; Flook et al., 1995). Based on the concatenated set of amino acid sequences from the 13 PCGs, phylogenetic analysis was performed using neighbor-joining (NJ) method with the MEGA version 5.0 program (Tamura et al., 2011).

3. Results

3.1. Genome organization and base composition

As shown in Fig. 1, the mitogenome of *D. pyloalis* is 15,298 bp in length and contains typical organization of insect mitochondrial genomes, including 13 PCGs (*atp6* and *atp8*, *cob*, *cox1–3*, *nad1-6*, *nad4L*), 22 tRNA genes, two mitochondrial ribosomal RNAs (*rrnS* and *rrnL*) and a A + T-rich region. The order of genes and the orientation of the

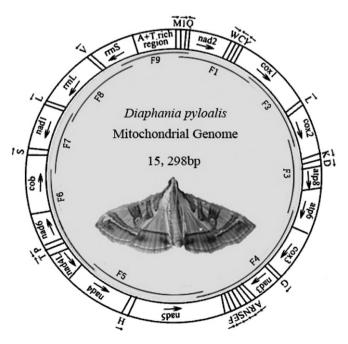


Fig. 1. Map of the mitogenome of *D. pyloalis.* tRNA genes are labeled according to the IUPAC-IUB. Single letter amino acids above the bar indicate coding sequence on major strand whereas below the bar indicates coding on minor strand. Anti-clockwise PCGs or rRNA genes are located on L strand and others are located on H strand.

Download English Version:

https://daneshyari.com/en/article/5906289

Download Persian Version:

https://daneshyari.com/article/5906289

Daneshyari.com