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Variability in D2/D3 segment sequences of several populations and pathotypes of the Potato Cyst Nematode (*Globodera rostochiensis*, *G. pallida*)

Ondřej Douda[1,4], Miloslav Zouhar[2] & Marek Renčo[3]

[1] Crop Research Institute, Drnovská 507, CZ–161 06 Praha 6, Czech Republic
[2] Czech University of Life Sciences, Kamýcká 129, CZ–165 21 Praha 6, Czech Republic
[3] Institute of Parasitology of the Slovak Academy of Sciences, Department of Environmental and Plant Parasitology, Hlinkova 3, SK-040 01 Košice, Slovakia
[4] corresponding author: douda@vurv.cz

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Abstract. The soil borne Potato Cyst Nematode [*Globodera rostochiensis* (Wollenweber, 1923), *Globodera pallida* (Stone, 1973)] is an important pest of potato in the Czech Republic. Although the use of cultivars of potato resistant to *G. rostochiensis* would decrease the risks to producers of potatoes, there are currently only a small number of cultivars that are resistant to *G. pallida* and therefore the spread of this species is likely to result in large losses in yield. Moreover, the level of infectivity of some pathotypes of *G. rostochiensis* is significantly higher than that of pathotype Ro1, which is currently the only pathotype present in both the Czech and Slovak Republics. For the effective use of resistant cultivars in the field the precise diagnostics of Potato Cyst Nematode pathotypes remains a key factor. The main aims of this work were: (i) to compare sequences of D2/D3 segments of the 28S rDNA gene obtained from three populations of *G. rostochiensis* and five populations of *G. pallida* and (ii) to place the researched *Globodera* populations into the broader context of the Heteroderidae. Resulting phylogenetic analysis showed significant differences between these two species of Potato Cyst Nematode, however, the situation is complicated by presence of a reference population of *G. pallida* in *G. rostochiensis* group. The taxonomic status of this reference population needs further verification.

Key words. Potato Cyst Nematode, *Globodera rostochiensis*, *Globodera pallida*, pathotype, D2/D3 segment.

INTRODUCTION

When considering potato production, two species of the quarantine Potato Cyst Nematode, *Globodera rostochiensis* (Wollenweber, 1923) and *Globodera pallida* (Stone, 1973) pose significant threats. Even though there are potato cultivars resistant to or tolerant of Potato Cyst Nematode it is nevertheless a major pest and subject to severe quarantine conditions. The situation is additionally complicated by the presence of different pathotypes of the Potato Cyst Nematode.

Pathotypes are defined as populations that are characterized by their ability to multiply in the tubers of certain clones and hybrids of *Solanum* spp. (Quader 2009). Some pathotypes are recognized by their almost total inability to multiply in particular cultivars of potato. In Europe five pathotypes of *G. rostochiensis* are recognized (Ro1–Ro5, international notation) and three of *G. pallida* (Pa1–Pa3) (Kort et al. 1977). For effective use of resistant cultivars in the field it is necessary to have a precise knowledge of the diagnostic characteristics of the different pathotypes.

The main goal of this work was to assess the homogeneity of the sequences of D2/D3 segments of the 28S rRNA gene obtained from three populations of *G. rostochiensis* and five populations of *G. pallida* and determine its value for diagnostic purposes and carry out a phylogenetic analysis of the Heteroderidae.

MATERIALS AND METHODS

The potato cyst nematode populations used in this study are listed in Table 1. Nematode cysts were extracted from soil using a Fenwick's can and in some cases already extracted cysts were obtained. DNA was extracted from single cysts using the GenElute™ Mammalian Genomic DNA Miniprep Kit (Sigma). Universal primers (Ellis et al. 1986, Courtright et al. 2000) D2A (5'-ACAAGTACCGTGAGGGAAAGTTG-3') and D3B (5'-TCGGAAGGAACCAGCTACTA-3') were used for amplifying the D2/D3 segments. PCR was carried out using the standard conditions as described by Douda et al. (2013).

PCR amplification was repeated with positive samples using LA polymerase (Fermentas). Purified DNA fragments (Min Elute PCR Purification Kit; Qiagen) were sequenced directly in both directions (Genomac International). Sequence alignment and calculation of alignment score was done using Clustal W software (www1) available on-line at default settings. The phylogenetic tree computation and its bootstrap analysis (1000 replicates) were done with the help of software package MEGA5 utilizing the maximum likelihood (ML) method. Sequences of additional species of the family Heteroreridae were obtained from the NCBI Gene Bank database and included in the phylogenetic analysis.

RESULTS

Alignment scores varied from 97 to 100 in all pair alignments of the sequences compared. The highest levels of variability were detected in the following comparisons: Ro1 vs. Ro3, Ro1 vs. Pa2A and Ro1 vs. PaKa. In contrast no differences were recorded when Ro5 was compared with the reference sequence of *G. pallida* obtained from the Gene Bank (pathotype unspecified, NCBI number GQ294489; Mandani et al. 2009, unpublished). The alignment score of the vast majority

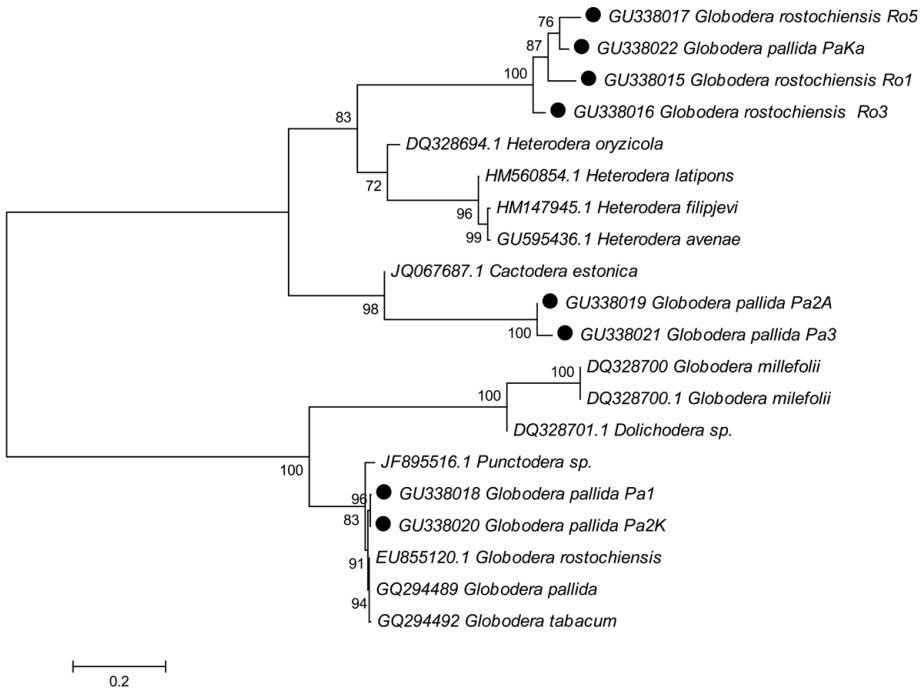

Fig. 1. Unrooted phylogenetic tree based on a maximum likelihood analysis of the D2/D3 rDNA segment sequences. Bootstrap values greater than 50% are given for the appropriate clades. Sequences recorded in this study are marked by black dots.

Table 1. Populations of the nematodes used in this study

Nr.	species	pathotype	origin	source	designation	GeneBank Nr.
1	*G. rostochiensis*	Ro1	Šluknov (Czech Republic)	V. Gaar	Ro1	GU338015
2	*G. rostochiensis*	Ro3	Obersteinbach (Germany)	M. Zouhar	Ro3	GU338016
3	*G. rostochiensis*	Ro5	Harmerz (Germany) (SPA)	V. Gaar	Ro5	GU338017
4	*G. pallida*	Pa1	UK	J. Pickup	Pa1	GU338018
5	*G. pallida*	Pa2	Aveest (Netherland)	V. Gaar	Pa2A	GU338019
6	*G. pallida*	Pa2	Kalle (France)	V. Gaar	Pa2K	GU338020
7	*G. pallida*	Pa3	Delmsen (Germany)	V. Gaar	Pa3	GU338021
8	*G. pallida*	unknown	Kašperské Hory (Czech Republic)	V. Gaar	PaKa	GU338022

of the comparisons varied from 98 to 99. In total 14 point deletions and three substitutions were recorded. More differences were detected in the sequences used in the phylogenetic analysis. For the complete sequence alignment see the Appendix 1.

Sequences of both species of Globodera Potato Cyst Nematodes were further compared using the BLAST algorithm. In both cases high levels of similarity were recorded when the sequences of *Globodera tabacum* (Lownsbery et Lownsbery, 1954) (NCBI number GQ294492; Madani et al. 2009, unpublished) were compared with those of *Globodera millefolii* (Kirjanova et Krall, 1965) (Subbotin et al. 2006; NCBI number DQ328700). The alignment score revealed more differences when compared with *G. millefolii* and smaller differences when compared with *G. tabacum* (score of 98 in most cases).

The phylogenetic analysis revealed three groups of populations of *Globodera*; the first group includes *G. rostochiensis* and surprisingly also *G. pallida* population PaKa, the second group two *G. pallida* populations that are more distant and constitute a separate clade and the third group includes *G. pallida* populations Pa1 and Pa2K, *G. rostochiensis* (NCBI nr. EU855120.1), *G. pallida* (GQ294489) and *G. tabacum* (GQ294492) – Fig. 1.

DISCUSSION

The little similarity in the D2/D3 sequences of *G. millefolii* (Subbotin et al. 2000, 2006) and *G. rostochiensis* and those of *G. pallida* indicate that in the case of these species this region has diagnostic potential. However this is not the case for *G. tabacum,* which was grouped in the clade containing three *G. pallida* populations. Interesting is the position of the *Heterodera* species between the clusters that included *G. rostochiensis* and *G. pallida,* respectively; all *Heterodera* species sequences used for the phylogenetic analysis were very homogeneous. Positions of *Cactodera estonica* (Kirjanova et Krall, 1963) and *Dolichodera* sp. on the tree closely mirrors the more distant relationship of these two species. Reason for the separation of the *G. pallida* populations into two separate clades is unclear, even two populations supposed to be of the same pathotype were separated. More research is needed to clarify the above mentioned taxonomic problems, probably including a comparison of the D2/D3 based phylogenetic analysis with one based on other sequence data.

The expansion segments of rDNA are a useful source of phylogenetic information regarding relatively recent evolutionary events (Subbotin et al. 2005). The structure of the D2/D3 segment can be used for solving taxonomic problems at different levels (Hillis & Dixon 1991). However, in the case of both species of Potato Cyst Nematode, it seems that the variability recorded for these segments is rather low. The divergence detected in the different pathotypes of Potato Cyst

Nematodes in this study is not different for that recorded for the two *G. pallida* populations of the same pathotype (Pa2A and PaKa).

Nevertheless the sequences of the D2/D3 expansion segments can at least be used in phylogenetic studies. The phylogram tree that resulted from using these sequences clearly revealed differences between the two species of Potato Cyst Nematode, however, the situation is complicated by the presence of the reference population of *G. pallida* in the *G. rostochiensis* group. The taxonomic status of this reference population needs to be verified, probably by sequencing another DNA segment; as does the sequence nr. EU855120.1 of the *G. rostochiensis* included in the *G. pallida* clade.

Acknowledgements

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REFERENCES

Courtright E. M., Wall D. H., Virginia R. A., Frisse L. M., Vida J. T. & Thomas W. K. 2000: Nuclear and mitochondrial DNA sequence diversity in the Antarctic nematode Scottnema lindsayae. *Journal of Nematology* **32**: 143–153.

Douda O., Marek M., Zouhar M. & Ryšánek P. 2013: Insights into the structure and phylogeny of the 28S rRNA expansion segments D2 and D3 of the plant-parasitic nematodes from the genus Ditylenchus (Nematoda: Anguininae), *Phytopathologia Mediterranea* **52**: 84−97.

Ellis R. E., Sulston J. E. & Coulson A. R. 1986: The rDNA of C. elegans: sequence and structure. *Nucleic Acids Research* **14**: 2345–2364.

Hillis D. M. & Dixon M. T. 1991: Ribosomal DNA: Molecular Evolution and Phylogenetic Inference. *Quarterly Review of Biology* **66**: 411–435.

Kort J., Ross H., Rumpenhorst H. J. & Stone A. R. 1977: An international scheme for the identification of pathotypes of potato cyst nematodes G. rostochiensis and G. pallida. *Nematologica* **23**: 333–339.

Quader M. 2009: Diagnostic methods for Potato Cyst Nematodes – Globodera spp. *PaDIL – Plant Biosecurity Toolbox*, *Potato Cyst Nematodes*, 1–6.

Subbotin S. A., Halford P. D., Warry A. & Perry R. N. 2000: Variations in ribosomal DNA sequences and phylogeny of Globodera parasitising solanaceous plants. *Nematology* **2**: 591–604.

Subbotin S. A., Sturhan D., Chizhov V., Vovlas N. & Baldwin J. G. 2006: Phylogenetic analysis of Tylenchida Thorne, 1949 as inferred from D2 and D3 expansion fragments of the 28S rRNA gene sequences. *Nematology* **8**: 455–474.

Subbotin S. A., Vovlas N., Crozzoli R., Sturhan D., Lamberti F., Moens M. & Baldwin J. G. 2005: Phylogeny of Criconematina Siddiqi, 1980 (Nematoda: Tylenchida) based on morphology and D2-D3 expansion segments of the 28S-rRNA gene sequences with application of a secondary structure model. *Nematology* **7**: 927–944.

WWW1: http://www.ebi.ac.uk/Tools/msa/clustalw2/

APPENDIX

Comparison of the consensus sequences of the populations included in this study. Original sequences are marked by bold letters and the rest of the data was obtained from the NCBI database.

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JF895516.1 Punctodera sp.       ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
DQ328701.1 Dolichodera sp.      ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
DQ328700   G. millefolii        ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
DQ328700.1 G. milefolii         ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338019 G. pallidaPa2A         ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338020 G. pallidaPa2K         ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338021 G. pallidaPa3          ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338018 G. pallidaPa1          ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338022 G. pallidaPaKa         ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCAT-CATCCGTG 49
GU338016 G. rostochiensisRo3    ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GU338015 G. rostochiensisRo1    ATGAGATGGAAACGAACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
EU855120.1 G. rostochiensis     ATGAGATGGAAACGMACAGAGCTGGCGTATCTGGTCTGCAYTCATCCGTG 50
GU338017 G. rostochiensisRo5    ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCAT-CATCCGTG 49
GQ294489 G. pallida             ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
GQ294492 G. tabacum             ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
JQ067687.1 Cactodera estonica   ATGAGATGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCATCCGTG 50
HM147945.1 Heterodera filipjevi ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCACCCGTC 50
GU595436.1 Heterodera avenae    ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCACCCGTC 50
HM560854.1 Heterodera latipons  ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCTGCATTCACCCGTT 50
DQ328694.1 Heterodera oryzicola ATGAGGTGGAAACGGACAGAGCTGGCGTATCTGGTCCGCATTCACCCGTT 50
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JF895516.1 Punctodera sp.       TGTTCTTGGGCGTTTGGGTTGCTACTCTCCAGACTGGG-ATGGTGCTTAT 99
DQ328701.1 Dolichodera sp.      TGTTCGTGGGCGTTTGGATTGCCACTTTCCAGCATGGG-ATGGTGTTCAT 99
DQ328700   G. millefolii        TGCTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
DQ328700.1 G. milefolii         TGCTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
GU338019 G. pallidaPa2A         TG-TCTTGGGCGTTTGGATTGCCAATCTCCAGACTGGG-ATGGTGTTCMT 98
GU338020 G. pallidaPa2K         TGTTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCMT 99
GU338021 G. pallidaPa3          TG-TCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCCT 98
GU338018 G. pallidaPa1          TGTTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
GU338022 G. pallidaPaKa         TGTTCTTGGGCGTTTGGATTG-CAATCTCCAGACTGGG-ATGGTGTTCAT 97
GU338016 G. rostochiensisRo3    TG-TCTTGGGCGTTTGGATTGCCAATCTCCAGACTGGG-ATGGTGTT-AT 97
GU338015 G. rostochiensisRo1    TGTTCTTGGGCG-TTGGATTG-CACTCTCCAGACTGGG-ATGGTGTTCAT 97
EU855120.1 G. rostochiensis     TGTTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
GU338017 G. rostochiensisRo5    TGTTCTTGGGCGTTTGGATTG-CACTCTCCAGACTGGG-ATGGTGTTCAT 97
GQ294489 G. pallida             TGTTCTTGGGCGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
GQ294492 G. tabacum             TGTTCTTGGACGTTTGGATTGCCACTCTCCAGACTGGG-ATGGTGTTCAT 99
JQ067687.1 Cactodera estonica   TGTTCTTGGGCGTTTG-GGTGCCACTCTCCAGATTGGG-ATGGTGTTCAT 98
HM147945.1 Heterodera filipjevi TGTTGTTGGGCG-TTGGGCTTCCTGCCTCCAGACTGGGGTTGGTTGTCTT 99
GU595436.1 Heterodera avenae    TGTTGTTGGACG-TTGGGCTTCCTGCCTCCAGACTGGGGTCGGTTGTCTT 99
HM560854.1 Heterodera latipons  TGTTGTTGGGCG-TTGGGCTTCCTTCCTCCAGACTGGGGTTGGTTGTCCT 99
DQ328694.1 Heterodera oryzicola TGTTGTTGTTCG-TTGGGCTGCCCAGCTCCAGACTGGG-TTGGCTGTCCA 98
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JF895516.1 Punctodera sp.      TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGACGCT 149
DQ328701.1 Dolichodera sp.     TCTGCTCGTGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
DQ328700   G. millefolii       TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
DQ328700.1 G. milefolii        TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
GU338019 G. pallidaPa2A        TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 148
GU338020 G. pallidaPa2K        TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
GU338021 G. pallidaPa3         TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 148
GU338018 G. pallidaPa1         TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
GU338022 G. pallidaPaKa        TCTGCTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 147
GU338016 G. rostochiensisRo3   TCTGYTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 147
GU338015 G. rostochiensisRo1   TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 147
EU855120.1 G. rostochiensis    TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
GU338017 G. rostochiensisRo5   TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 147
GQ294489 G. pallida            TCTGTTCAGGGGCTCATGGAGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
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HM147945.1 Heterodera filipjevi TCTGTTCAGCGGCTGATGGGGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
GU595436.1 Heterodera avenae    TCTGTTCAGCGGCTGATGGGGCATTTGCAGGCGGAGTGCGCTGAGATGCT 149
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GU338019 G. pallidaPa2A         CGGGACAGCTGCATGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 198
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GU338021 G. pallidaPa3          CGGGACAGCTGCATGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 198
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GU338017 G. rostochiensisRo5    CGGAGCAGCTGCATGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 197
GQ294489 G. pallida             CGGAGCAGCTGCATGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 199
GQ294492 G. tabacum             CGGAGCAGCTGCATGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 199
JQ067687.1 Cactodera estonica   CGGGGCAGCTGTATGAGCTTGACTTTGAGGCCAGCCCTTCGGGGTCTGGT 198
HM147945.1 Heterodera filipjevi CGGGGTAGCTGCGTGAACTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 199
GU595436.1 Heterodera avenae    CGGGGTAGCTGCGTGAACTCGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 199
HM560854.1 Heterodera latipons  CGGGGTAGCTGCGTGAGCTCGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 199
DQ328694.1 Heterodera oryzicolaCGGGGCAGCGGTGTGAGCTTGGCTTTGAGGCCAGCCCTTCGGGGTCTGGT 198
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DQ328701.1 Dolichodera sp.      ACCCGGGCTGGGGGAGTGTTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
DQ328700   G. millefolii        ACCCGGGCTGGGGGAGTGTTGTTTGTTCTGGGTGCTGAGTGGTGTGCAAT 249
DQ328700.1 G. milefolii         ACCCGGGCTGGGGGAGTGTTGTTTGTTCTGGGTGCTGAGTGGTGTGCAAT 249
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GU338020 G. pallidaPa2K         ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
GU338021 G. pallidaPa3          ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 247
GU338018 G. pallidaPa1          ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
GU338022 G. pallidaPaKa         ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 246
GU338016 G. rostochiensisRo3    ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 246
GU338015 G. rostochiensisRo1    ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 246
EU855120.1 G. rostochiensis     ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
GU338017 G. rostochiensisRo5    ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 246
GQ294489 G. pallida             ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
GQ294492 G. tabacum             ACCCGGGCTGTGGGAGTGCTGTTTGTTCTGGGTGCTGAGTG-TGTGCAAT 248
JQ067687.1 Cactodera estonica    CCCGGGTCGGGGGAGTGCTGTTTGCTCTGGGTGGTGTGCT-GGTGCAAT 247
HM147945.1 Heterodera filipjevi ACCCGGGCCAGGGGAATGCTGTTTACTCTGGGTG-AGAGTG---TGCAAT 245
GU595436.1 Heterodera avenae    ACCCGGGTCGGGGGAATGCTGTTTACTCTGGGTG-AGAGTG---TGCAAT 245
HM560854.1 Heterodera latipons  ACCCGGGCCGGGGGAATGCTGTTTGCTCTGGGTG-AACGTG---TGCAAT 245
DQ328694.1 Heterodera oryzicolaACCCGGGCCGGGGGAATGCTGTTTGTCCTGGGTGCCATGAG---CACAAT 245
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DQ328700   G. millefolii        GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 299
DQ328700.1 G. milefolii         GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 299
GU338019 G. pallidaPa2A         GGCAACGGGTCCGTGTTGGTTTGAGCTGGTGGTTGGTGGCGGTCGCGTGC 297
GU338020 G. pallidaPa2K         GGCAACGGGTCCGTGTTGGTTTGAGCTGGTGGTTGGTGGCGGTCGCGTGC 298
GU338021 G. pallidaPa3          GGCAACGGGTCCGTGTTGGTTTGAGCTGGTGGTTGGTGGCGGTCGCGTGC 297
GU338018 G. pallidaPa1          GGCAACGGGTCCGTGTTGGTTTGAGCTGGTGGTTGGTGGCGGTCGCGTGC 298
GU338022 G. pallidaPaKa         GGCAACGGGTCCGTGTTGGTTTGAGCTGGTGGTTGGTGGCGGTCGCGTGC 296
GU338016 G. rostochiensisRo3    GGCAACGGGTCCGTGTTGGTTTGAGCTGGYGGTYGGTGGCGGTCGCGTGC 296
GU338015 G. rostochiensisRo1    GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 296
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EU855120.1 G. rostochiensis    KGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 298
GU338017 G. rostochiensisRo5   GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 296
GQ294489 G. pallida            GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 298
GQ294492 G. tabacum            GGCAACGGGTCCGTGTTGGTTTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 298
JQ067687.1 Cactodera estonica  GGCAACGGGCCCGTGTTGGATTGAGCTGGCGGTCGGTGGCGGTCGCGTGC 297
HM147945.1 Heterodera filipjevi GGTTTCGGGTCCGTGTTGGCTCGAGCTGAGTGTCGGTGGCGGTCGCATGC 295
GU595436.1 Heterodera avenae   GGTTTCGGGTCCGTGTTGGTTCGAGCTGAGTGTCGGTGGCGGTCGCATGC 295
HM560854.1 Heterodera latipons GGTTTCGGGTCCGTGTTGGTTCGAGCTGAGGGTTGGTGGCGGTCGCATGC 295
DQ328694.1 Heterodera oryzicolaGGTCACGGGTCCGTGTTGGTCCGAGCTGACGGTCGGTGGCGGTCGCATGC 295
                               *  :**** *********   ******.   * ******.*****.***

JF895516.1 Punctodera sp.      GACACGTGCCAGCAGTTAGTTCGGTCCTGCTCGGGCTCTCTTT-GCATGT 347
DQ328701.1 Dolichodera sp.     GACACGTGCCAGCAGTTAGTTCGGTCCTGCGCGGGCTCTCATTTGCATGT 348
DQ328700   G. millefolii       GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 348
DQ328700.1 G. milefolii        GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 348
GU338019 G. pallidaPa2A        GACACGTGCCGGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 346
GU338020 G. pallidaPa2K        GACACGTGCCGGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 347
GU338021 G. pallidaPa3         GACACGTGCCGGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 346
GU338018 G. pallidaPa1         GACACGTGCCGGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 347
GU338022 G. pallidaPaKa        GACACGTGCCGGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 345
GU338016 G. rostochiensisRo3   GACACGTGCCRGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 345
GU338015 G. rostochiensisRo1   GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 345
EU855120.1 G. rostochiensis    GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 347
GU338017 G. rostochiensisRo5   GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 345
GQ294489 G. pallida            GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 347
GQ294492 G. tabacum            GACACGTGCCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 347
JQ067687.1 Cactodera estonica  GACACGTACCAGCAGTCAGTTCGGTCCTGCTCGGGCTCTCATT-GCATGT 346
HM147945.1 Heterodera filipjevi GACACGTACCAGCAATCAGTTCGGTCCAGCTCGGGCTCTCATTTGTGCGT 345
GU595436.1 H.avenae            GACACGTACCAGCAATCAGTTCGGTCCAGCTCGGGCTCTCATTTGTGCGT 345
HM560854.1 H. latipons         GACACGTACCAGCAGTCAGTTCGGTCCAGCTCGGGCTCYCATTTGTGCGT 345
DQ328694.1 H. oryzicola        GACACGTACTGGCAGCCAGTTCGGTCCAGCTCGGGCTCTCATTTGTGTGT 345
                               *******.*  ***.  **********:** ******* *:** * . **

JF895516.1 Punctodera sp.      TCTCAGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
DQ328701.1 Dolichodera sp.     TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 398
DQ328700   G. millefolii       TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 398
DQ328700.1 G. milefolii        TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 398
GU338019 G. pallidaPa2A        TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 396
GU338020 G. pallidaPa2K        TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
GU338021 G. pallidaPa3         TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 396
GU338018 G. pallidaPa1         TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
GU338022 G. pallidaPaKa        TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 395
GU338016 G. rostochiensisRo3   TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 395
GU338015 G. rostochiensisRo1   TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 395
EU855120.1 G. rostochiensis    TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
GU338017 G. rostochiensisRo5   TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 395
GQ294489 G. pallida            TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
GQ294492 G. tabacum            TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 397
JQ067687.1 Cactodera estonica  TCTCGGTGTAAAAGCCGGTCATCTGTCCGACCCGTCTTGAAACACGGACC 396
HM147945.1 Heterodera filipjevi TCTCGGTGTAAAAGCCGGTTATCTGTCCGACCCGTCTTGAAACACGGACC 395
GU595436.1 Heterodera avenae   TCTCGGTGTAAAAGCCGGTTATCTGTCCGACCCGTCTTGAAACACGGACC 395
HM560854.1 Heterodera latipons TCTCGGTGTAAAAGCCGGTTATCTGTTCGACCCGTCTTGAAACACGGACC 395
DQ328694.1 Heterodera oryzicolaTCTCGGTGTAAAAGCCGGTCATCTGTTCGACCCGTCTTGAAACACGGACC 395
                               ****.************** ****** ************************

JF895516.1 Punctodera sp.      AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGTGTTGAAAACCCAAGGGCG 447
DQ328701.1 Dolichodera sp.     AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 448
DQ328700   G. millefolii       AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 448
DQ328700.1 G. milefolii        AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 448
GU338019 G. pallidaPa2A        AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 446
GU338020 G. pallidaPa2K        AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 447
GU338021 G. pallidaPa3         AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 446
GU338018 G. pallidaPa1         AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 447
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GU338022 G. pallidaPaKa          AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 445
GU338016 G. rostochiensisRo3     AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 445
GU338015 G. rostochiensisRo1     AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 445
EU855120.1 G. rostochiensis      AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 447
GU338017 G. rostochiensisRo5     AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 445
GQ294489 G. pallida              AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 447
GQ294492 G. tabacum              AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGAGTTGAAAACCCAAGGGCG 447
JQ067687.1 Cactodera estonica    AAGGAGTTTAGCGTGTGCGCGAGTCATTGGGTGTTGAAAACCCAAAGGCG 446
HM147945.1 Heterodera filipjevi  AAGGAGTTTAGCGTATGCGCGAGTCATTGGGTGTTGAAAACCCAAAGGCG 445
GU595436.1 Heterodera avenae     AAGGAGTTTAGCGTATGCGCGAGTCATTGGGTGTTGAAAACCCAAAGGCG 445
HM560854.1 Heterodera latipons   AAGGAGTTTAGCGTATGCGCGAGTCATTGGGTGTTGAAAACCCAAAGGCG 445
DQ328694.1 Heterodera oryzicolaAAGGAGTTTAGCGTATGCGCGAGTCATTGGGTGTTGAAAACCCAAAGGCG 445
                                 **************.****************:*************.****

JF895516.1 Punctodera sp.        TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCCCGTGCACC 497
DQ328701.1 Dolichodera sp.       TAATGAAAGTGAAGGCCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 498
DQ328700   G. millefolii         TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCCCGTGCACC 498
DQ328700.1 G. milefolii          TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCCCGTGCACC 498
GU338019 G. pallidaPa2A          TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 496
GU338020 G. pallidaPa2K          TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 497
GU338021 G. pallidaPa3           TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 496
GU338018 G. pallidaPa1           TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 497
GU338022 G. pallidaPaKa          TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 495
GU338016 G. rostochiensisRo3     TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 495
GU338015 G. rostochiensisRo1     TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 495
EU855120.1 G. rostochiensis      TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 497
GU338017 G. rostochiensisRo5     TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 495
GQ294489 G. pallida              TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 497
GQ294492 G. tabacum              TAATGAAAGTGAAGGTCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACT 497
JQ067687.1 Cactodera estonica    TAATGAAAGTGAAG-TCTCCTTGCGGAGCTGATGTGTGATCTCGTGCACC 495
HM147945.1 Heterodera filipjevi  TAATGAAAGTGAAGGCATCCTTGCGGAGCTGATGTGTGATCCCTGGCACT 495
GU595436.1 Heterodera avenae     TAATGAAAGTGAAGGCATCCTTGCGGAGCTGATGTGTGATCCCTGGCACT 495
HM560854.1 Heterodera latipons   TAATGAAAGTGAAGGCGTCCTTGCGGAGCTGATGTGTGATCCCTGGCACT 495
DQ328694.1 Heterodera oryzicolaTAATGAAAGTGAAGGCGTCCTTGCGGAGCTGATGTGTGATCCCGGGCACC 495
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JF895516.1 Punctodera sp.        CCGGTGTGCGGGCGCAACATAGTCCCGTTCCTATCGCATGCGATGGGGCG 547
DQ328701.1 Dolichodera sp.       CCGGTGTGCGAGCGCAACATAGTCCCGTCCCTATTGCATGCAATGGGGCG 548
DQ328700   G. millefolii         ACGGTGTGCGGGCGCAACATAGTCCCGTTCCTATCGCATGCGATGGGGCG 548
DQ328700.1 G. milefolii          ACGGTGTGCGGGCGCAACATAGTCCCGTTCCTATCGCATGCGATGGGGCG 548
GU338019 G. pallidaPa2A          CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 546
GU338020 G. pallidaPa2K          CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 547
GU338021 G. pallidaPa3           CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 546
GU338018 G. pallidaPa1           CCGGTGTGCGGGCGCAACATAGTCCCGTCCCAATCGCATGCGATGGGGCG 547
GU338022 G. pallidaPaKa          CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 545
GU338016 G. rostochiensisRo3     CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 545
GU338015 G. rostochiensisRo1     CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 545
EU855120.1 G. rostochiensis      CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 547
GU338017 G. rostochiensisRo5     CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 545
GQ294489 G. pallida              CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 547
GQ294492 G. tabacum              CCGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 547
JQ067687.1 Cactodera estonica    ACGGTGTGCGGGCGCAACATAGTCCCGTCCCGATCGCATGCGATGGGGCG 545
HM147945.1 Heterodera filipjevi  GCGGTGTTGGGGCGCAACATAGTCCCGTCTCGATCGCATGCGATGGGGCG 545
GU595436.1 Heterodera avenae     GCGGTGTTGGGGCGCAACATAGTCCCGTCTCGATCGCATGCGATGGGGCG 545
HM560854.1 Heterodera latipons   GCGGTGTTGGGGCGCAACATAGTCCCGTCTCGATCGCATGCGATGGGGCG 545
DQ328694.1 Heterodera oryzicolaCCGGTGCTCGGGCGCAACATAGTCCCGTCTCGATTGCATGCAATGGGGCG 545
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JF895516.1 Punctodera sp.        GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
DQ328701.1 Dolichodera sp.       GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 598
DQ328700   G. millefolii         GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 598
DQ328700.1 G. milefolii          GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 598
GU338019 G. pallidaPa2A          GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 596
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GU338020 G. pallidaPa2K          GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
GU338021 G. pallidaPa3           GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 596
GU338018 G. pallidaPa1           GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
GU338022 G. pallidaPaKa          GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
GU338016 G. rostochiensisRo3     GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
GU338015 G. rostochiensisRo1     GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
EU855120.1 G. rostochiensis      GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
GU338017 G. rostochiensisRo5     GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
GQ294489 G. pallida              GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
GQ294492 G. tabacum              GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 597
JQ067687.1 Cactodera estonica    GAGACAGAGCGTACGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
HM147945.1 Heterodera filipjevi  GAGACAGAGCGTATGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
GU595436.1 Heterodera avenae     GAGACAGAGCGTATGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
HM560854.1 Heterodera latipons   GAGACAGAGCGTATGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
DQ328694.1 Heterodera oryzicolaGAGACAGAGCGTATGCGCTGAGACCCGAAAGATGGTGAACTATTCCTGAG 595
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JF895516.1 Punctodera sp.        CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
DQ328701.1 Dolichodera sp.       CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 648
DQ328700   G. millefolii         CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 648
DQ328700.1 G. milefolii          CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 648
GU338019 G. pallidaPa2A          CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCG-AGCGATTCTGACG 645
GU338020 G. pallidaPa2K          CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
GU338021 G. pallidaPa3           CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 646
GU338018 G. pallidaPa1           CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
GU338022 G. pallidaPaKa          CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
GU338016 G. rostochiensisRo3     CAGGATGAAGCCAGAGGAAACTCTGGTGG-AGTCCG-AGCGATTCTGACG 643
GU338015 G. rostochiensisRo1     CAGGATG-AGCCAGAGGAACCTCTGGTGGAAGTCCGAAGCGATTCTGACG 644
EU855120.1 G. rostochiensis      CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
GU338017 G. rostochiensisRo5     CAGGATGAAGCCAGAGG-AACTCTGGTGG-AGTCCG-AGCGATTCTGACG 642
GQ294489 G. pallida              CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
GQ294492 G. tabacum              CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 647
JQ067687.1 Cactodera estonica    CAGGACGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
HM147945.1 Heterodera filipjevi  CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
GU595436.1 Heterodera avenae     CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
HM560854.1 Heterodera latipons   CAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
DQ328694.1 Heterodera oryzicolaCAGGATGAAGCCAGAGGAAACTCTGGTGGAAGTCCGAAGCGATTCTGACG 645
                                 ***** * ********* *.********** ****** *************

JF895516.1 Punctodera sp.          TGCAAATCGATCG 660
DQ328701.1 Dolichodera sp.         TGCAAATCGATCG 661
DQ328700   G. millefolii           TGCAAATCGATCG 661
DQ328700.1 G. milefolii            TGCAAATCGATCG 661
GU338019 G. pallidaPa2A            TGCAAATCGATCG 658
GU338020 G. pallidaPa2K            TGCAAATCGATCG 660
GU338021 G. pallidaPa3             TGCAAATCGATCG 659
GU338018 G. pallidaPa1             TGCAAATCGATCG 660
GU338022 G. pallidaPaKa            TGCAAATCGATCG 658
GU338016 G. rostochiensisRo3       TGCAAATCGATCG 656
GU338015 G. rostochiensisRo1       TGCAAATCGATCG 657
EU855120.1 G. rostochiensis        TGCAAATCGATCG 660
GU338017 G. rostochiensisRo5       TGCAAATCGATCG 655
GQ294489 G. pallida                TGCAAATCGATCG 660
GQ294492 G. tabacum                TGCAAATCGATCG 660
JQ067687.1 Cactodera estonica      TGCAAATCGATCG 658
HM147945.1 Heterodera filipjevi    TGCAAATCGATCG 658
GU595436.1 Heterodera avenae       TGCAAATCGATCG 658
HM560854.1 Heterodera latipons     TGCAAATCGATCG 658
DQ328694.1 Heterodera oryzicola    TGCAAATCGATCG 658
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