GEPHE SUMMARY

Gephebase Gene
CYP6CY3-CYP6CY4 (https://www.gephebase.org/search-criteria?/and+Gene Gephebase=^CYP6CY3-CYP6CY4^#gephebase-summary-title)

GepheID
GP00001473

Entry Status
Published

Main curator
Prigent

PHENOTYPIC CHANGE

Trait Category
Physiology (https://www.gephebase.org/search-criteria?/and+Trait Category=^Physiology^#gephebase-summary-title)

Trait
Xenobiotic resistance (insecticide; neonicotinoid; host plant) (https://www.gephebase.org/search-criteria?/and+Trait=^Xenobiotic resistance (insecticide; neonicotinoid; host plant)^#gephebase-summary-title)

Trait State in Taxon A
Peach-potato aphid 4106A does not survive for 144h on a diet containing 30ppm nicotine ; tobacco aphid JR with 100% mortality at 144h on a diet containing 320ppm nicotine

Trait State in Taxon B
Tobacco aphid 5410R with 7% mortality at 144h on a diet containing 320ppm nicotine ; tobacco aphid 5191A survive for 144h on a diet containing 30ppm nicotine

Ancestral State
Taxon A

Taxonomic Status
Intraspecific (https://www.gephebase.org/search-criteria?/and+Taxonomic Status=^Intraspecific^#gephebase-summary-title)

Taxon A

Latin Name
Myzus persicae (https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=^Myzus persicae^#gephebase-summary-title)

Common Name
green peach aphid

Synonyms
Myzus (Nectarosiphon) persicae; green peach aphid; peach-potato aphid; Myzus persicae (Sulzer, 1776); Myzus persiceae

Rank
species

Lineage
cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Mandibulata; Pancrustacea; Hexapoda; Insecta; Dicondylia; Pterygota; Neoptera; Paraneoptera; Hemiptera; Sternorrhyncha; Aphidomorpha; Aphidoidea; Aphididae; Aphidinae; Macrosiphini; Myzus

Parent
Myzus () - (Rank: genus) (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 13163)

NCBI Taxonomy ID
13164 (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 13164)

is Taxon A an Infraspecies?
Yes

Taxon A Description
Peach-potato aphid 4106A does not survive for 144h on a diet containing 30ppm nicotine ; tobacco aphid JR with 100% mortality at 144h on a diet containing 320ppm nicotine

Taxon B

Latin Name
Myzus persicae (https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=^Myzus persicae^#gephebase-summary-title)

Common Name
green peach aphid

Synonyms
Myzus (Nectarosiphon) persicae; green peach aphid; peach-potato aphid; Myzus persicae (Sulzer, 1776); Myzus persiceae

Rank
species

Lineage
cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Mandibulata; Pancrustacea; Hexapoda; Insecta; Dicondylia; Pterygota; Neoptera; Paraneoptera; Hemiptera; Sternorrhyncha; Aphidomorpha; Aphidoidea; Aphididae; Aphidinae; Macrosiphini; Myzus

Parent
Myzus () - (Rank: genus) (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 13163)

NCBI Taxonomy ID
13164 (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 13164)

is Taxon B an Infraspecies?
Yes

Taxon B Description
tobacco aphid 5410R with 7% mortality at 144h on a diet containing 320ppm nicotine ; tobacco aphid 5191A survive for 144h on a diet containing 30ppm nicotine

GENOTYPIC CHANGE

Generic Gene Name
CYP6CY3

Synonyms
-

String
-

Sequence Similarities
Belongs to the cytochrome P450 family.

GO - Molecular Function
GO:0020037 : heme binding (https://www.ebi.ac.uk/QuickGO/term/GO:0020037)
GO:0005506 : iron ion binding (https://www.ebi.ac.uk/QuickGO/term/GO:0005506)

UniProtKB Myzus persicae
V5SQ25 (http://www.uniprot.org/uniprot/V5SQ25)

GenebankID or UniProtKB
()

GO:0004497 : monooxygenase activity (https://www.ebi.ac.uk/QuickGO/term/GO:0004497)
GO:0016705 : oxidoreductase activity, acting on paired donors, with incorporation or reduction of molecular oxygen (https://www.ebi.ac.uk/QuickGO/term/GO:0016705)

GO - Biological Process

-

GO - Cellular Component

GO:0016021 : integral component of membrane (https://www.ebi.ac.uk/QuickGO/term/GO:0016021)

Presumptive Null

No (https://www.gephebase.org/search-criteria?/and+Presumptive Null=^No^#gephebase-summary-title)

Molecular Type

Gene Amplification (https://www.gephebase.org/search-criteria?/and+Molecular Type=^Gene Amplification^#gephebase-summary-title)

Aberration Type

Insertion (https://www.gephebase.org/search-criteria?/and+Aberration Type=^Insertion^#gephebase-summary-title)

Insertion Size

100-1000 kb

Molecular Details of the Mutation

gene amplification (from 2 to 14-100 copies) - CYP6CY3 and neighboring gene CYP6CY4 are duplicated in M. p. nicotianae as a large amplicon of ~325â€‰kb creating characteristic breakpoints identifying the region. CYP6CY4 and CYP6CY3 are highly effective at metabolizing nicotine to its nontoxic metabolite cotinine.

Experimental Evidence

Candidate Gene (https://www.gephebase.org/search-criteria?/and+Experimental Evidence=^Candidate Gene^#gephebase-summary-title)

Main Reference

Gene amplification and microsatellite polymorphism underlie a recent insect host shift. (2013) (https://pubmed.ncbi.nlm.nih.gov/24218582)

Authors

Bass C; Zimmer CT; Riveron JM; Wilding CS; Wondji CS; Kaussmann M; Field LM; Williamson MS; Nauen R

Abstract

Host plant shifts of herbivorous insects may be a first step toward sympatric speciation and can create new pests of agriculturally important crops; however, the molecular mechanisms that mediate this process are poorly understood. Certain races of the polyphagous aphid Myzus persicae have recently adapted to feed on tobacco (Myzus persicae nicotianae) and show a reduced sensitivity to the plant alkaloid nicotine and cross-resistance to neonicotinoids a class of synthetic insecticides widely used for control. Here we show constitutive overexpression of a cytochrome P450 (CYP6CY3) allows tobacco-adapted races of M. persicae to efficiently detoxify nicotine and has preadapted them to resist neonicotinoid insecticides. CYP6CY3, is highly overexpressed in M. persicae nicotianae clones from three continents compared with M. persicae s.s. and expression level is significantly correlated with tolerance to nicotine. CYP6CY3 is highly efficient (compared with the primary human nicotine-metabolizing P450) at metabolizing nicotine and neonicotinoids to less toxic metabolites in vitro and generation of transgenic Drosophila expressing CYP6CY3 demonstrate that it confers resistance to both compounds in vivo. Overexpression of CYP6CY3 results from the expansion of a dinucleotide microsatellite in the promoter region and a recent gene amplification, with some aphid clones carrying up to 100 copies. We conclude that the mutations leading to overexpression of CYP6CY3 were a prerequisite for the host shift of M. persicae to tobacco and that gene amplification and microsatellite polymorphism are evolutionary drivers in insect host adaptation.

Additional References

Amplification of a cytochrome P450 gene is associated with resistance to neonicotinoid insecticides in the aphid Myzus persicae. (2010) (https://pubmed.ncbi.nlm.nih.gov/20585623)
Gene amplification and microsatellite polymorphism underlie a recent insect host shift. (2013) (https://pubmed.ncbi.nlm.nih.gov/24218582)
The genetic architecture of a host shift: An adaptive walk protected an aphid and its endosymbiont from plant chemical defenses. (2020) (https://pubmed.ncbi.nlm.nih.gov/32494722)

RELATED GEPHE

Related Genes

8 (acetyl-CoA carboxylase (ACC), Acetylcholinesterase (Ace-1), CYP6CY3, esterase E4, esterase FE4, nAChR, para (kdr), resistance to dieldrin) (https://www.gephebase.org/search-criteria?/or+Taxon ID=^13164^/and+Trait=Xenobiotic resistance/and+groupHaplotypes=true#gephebase-summary-title)

Related Haplotypes

No matches found.

EXTERNAL LINKS

COMMENTS

Massive Gene Aplification ; tobacco-adapted clones showing a 7- to 49- fold increase in gene copy number (from 2 copies in the diploid M. persicae s.s. clones to 100 copies in the M. persicae nicotianae clones). @TE Additional copies of CYP6CY3 were found at a novel locus as part of a much smaller (~14 kb) amplicon associated with two transposable element insertions. These nested insertions occur immediately adjacent to the 5â€² breakpoint; strongly suggesting they played a role in the mobilization of CYP6CY3 to the new loci; either indirectly by acting as substrates for non-allelic homologous recombination or directly via alternative transposition. Sequencing of the CYP6CY3 coding sequence and 5â€² flanking region supports a single origin and then global spread of the amplification event and also suggests it occurred recently.