

GEPHE SUMMARY

Gephebase Gene	GepheID
CYP6CY3-CYP6CY4 (https://www.gephebase.org/search-criteria?/and+Gene	GP00001473
Gephebase= [^] CYP6CY3-CYP6CY4 [#] gephebase-summary-title)	Main curator
Entry Status	Prigent
Published	

PHENOTYPIC CHANGE

Trait Category	
Trait	
Xenobiotic resistance (insecticide; neonicotinoid; host plant) (#gephbase-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 (#gephbase-summary-title)	
Taxon A	Latin Name
Myzus persicae (#gephbase-summary-title)	Myzus persicae (#gephbase-summary-title)
green peach aphid	Common Name
Myzus (Nectarosiphon) persicae; green peach aphid; peach-potato aphid; Myzus persicae (Sulzer, 1776); Myzus persiceae	Synonyms
species	Rank
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	Lineage
Myzus () - (Rank: genus) (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=13163)	Parent
13164 (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=13164)	NCBI Taxonomy ID
Yes	is Taxon A an Infraspecies?
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 A Description
Taxon B	Latin Name
Myzus persicae (#gephbase-summary-title)	Myzus persicae (#gephbase-summary-title)
green peach aphid	Common Name
Myzus (Nectarosiphon) persicae; green peach aphid; peach-potato aphid; Myzus persicae (Sulzer, 1776); Myzus persiceae	Synonyms
species	Rank
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	Lineage
Myzus () - (Rank: genus) (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=13163)	Parent
13164 (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=13164)	NCBI Taxonomy ID
Yes	is Taxon B an Infraspecies?
Peach-potato 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	Taxon B Description

GENOTYPIC CHANGE

CYP6CY3	Generic Gene Name	V5SQ25 (http://www.uniprot.org/uniprot/V5SQ25)	UniProtKB Myzus persicae
	Synonyms	0	GenebankID or UniProtKB
	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)			

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 ~325 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 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 Amplification ; 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 5' 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 5' flanking region supports a single origin and then global spread of the amplification event and also suggests it occurred recently.