

GEPHE SUMMARY

|   |                |            |              |
|---|----------------|------------|--------------|
| cytochrome b ( <a href="https://www.gephebase.org/search-criteria?/and+Gene">https://www.gephebase.org/search-criteria?/and+Gene</a><br>Gephebase= <sup>^</sup> cytochrome b <sup>^</sup> #gephebase-summary-title) | Gephebase Gene | GP00002599 | GepheID      |
| Published   | Entry Status   | Courtier   | Main curator |

PHENOTYPIC CHANGE

|  |  |  |  |
|--|--|--|--|
| Physiology ( <a href="https://www.gephebase.org/search-criteria?/and+Trait">https://www.gephebase.org/search-criteria?/and+Trait</a><br>Category= <sup>^</sup> Physiology <sup>^</sup> #gephebase-summary-title)   | Trait Category   |  |  |
| Xenobiotic resistance (insecticide ; bifenazate) ( <a href="https://www.gephebase.org/search-criteria?/and+Trait=&lt;sup&gt;^&lt;/sup&gt;Xenobiotic resistance (insecticide ; bifenazate)&lt;sup&gt;^&lt;/sup&gt;#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Trait=<sup>^</sup>Xenobiotic resistance (insecticide ; bifenazate)<sup>^</sup>#gephebase-summary-title</a> ) | Trait  |  |  |
| Tetranychus urticae - sensitive  | Trait State in Taxon A   |  |  |
| Tetranychus urticae - resistant to bifenazate  | Trait State in Taxon B   |  |  |
| Taxon A  | Ancestral State  |  |  |
| Interspecific ( <a href="https://www.gephebase.org/search-criteria?/and+Taxonomic">https://www.gephebase.org/search-criteria?/and+Taxonomic</a><br>Status= <sup>^</sup> Interspecific <sup>^</sup> #gephebase-summary-title)   | Taxonomic Status   |  |  |
|  | Taxon A  | Taxon B  |  |
|  | Latin Name   | Latin Name   |  |
| Tetranychus urticae<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=&lt;sup&gt;^&lt;/sup&gt;Tetranychus urticae&lt;sup&gt;^&lt;/sup&gt;#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=<sup>^</sup>Tetranychus urticae<sup>^</sup>#gephebase-summary-title</a> )   | Tetranychus urticae<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=&lt;sup&gt;^&lt;/sup&gt;Tetranychus urticae&lt;sup&gt;^&lt;/sup&gt;#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=<sup>^</sup>Tetranychus urticae<sup>^</sup>#gephebase-summary-title</a> ) | Tetranychus urticae<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=&lt;sup&gt;^&lt;/sup&gt;Tetranychus urticae&lt;sup&gt;^&lt;/sup&gt;#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon and Synonyms=<sup>^</sup>Tetranychus urticae<sup>^</sup>#gephebase-summary-title</a> ) |  |
|  | Common Name  | Common Name  |  |
| two-spotted spider mite  | two-spotted spider mite  | two-spotted spider mite  |  |
|  | Synonyms   | Synonyms   |  |
| two-spotted spider mite; red spider mite; twospotted mite; Tetranychus urticae Koch, 1836  | two-spotted spider mite; red spider mite; twospotted mite; Tetranychus urticae Koch, 1836  | two-spotted spider mite; red spider mite; twospotted mite; Tetranychus urticae Koch, 1836  |  |
|  | Rank   | Rank   |  |
| species  | species  | species  |  |
|  | Lineage  | Lineage  |  |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Chelicerata; Arachnida; Acari; Acariformes; Trombidiformes; Prostigmata; Eleutherengona; Raphignathae; Tetranychoidae; Tetranychidae; Tetranychus   | cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Chelicerata; Arachnida; Acari; Acariformes; Trombidiformes; Prostigmata; Eleutherengona; Raphignathae; Tetranychoidae; Tetranychidae; Tetranychus   | cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Chelicerata; Arachnida; Acari; Acariformes; Trombidiformes; Prostigmata; Eleutherengona; Raphignathae; Tetranychoidae; Tetranychidae; Tetranychus   |  |
|  | Parent   | Parent   |  |
| Tetranychus () - (Rank: genus)<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263</a> )  | Tetranychus () - (Rank: genus)<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263</a> )  | Tetranychus () - (Rank: genus)<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32263</a> )  |  |
|  | NCBI Taxonomy ID   | NCBI Taxonomy ID   |  |
| 32264<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264</a> )   | 32264<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264</a> )   | 32264<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id= 32264</a> )   |  |
|  | is Taxon A an Intraspecies?  | is Taxon B an Intraspecies?  |  |
| No   | No   | No   |  |

GENOTYPIC CHANGE

|  |                         |  |                         |
|--|-------------------------|--|-------------------------|
| UQCRFS1  | Generic Gene Name       | P47985 ( <a href="http://www.uniprot.org/uniprot/P47985">http://www.uniprot.org/uniprot/P47985</a> ) | UniProtKB Homo sapiens  |
| RIP1; RIS1; RISP; UQCR5  | Synonyms                | ()   | GenebankID or UniProtKB |
| 9606.ENSPP00000306397<br>( <a href="http://string-db.org/newstring_cgi/show_network_section.pl?identifier=9606.ENSPP00000306397">http://string-db.org/newstring_cgi/show_network_section.pl?identifier=9606.ENSPP00000306397</a> ) | String                  |  |                         |
| -  | Sequence Similarities   |  |                         |
|  | GO - Molecular Function |  |                         |
| GO:0046872 : metal ion binding ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0046872">https://www.ebi.ac.uk/QuickGO/term/GO:0046872</a> )   |                         |  |                         |
| GO:0051537 : 2 iron, 2 sulfur cluster binding<br>( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0051537">https://www.ebi.ac.uk/QuickGO/term/GO:0051537</a> )   |                         |  |                         |
| GO:0008121 : ubiquinol-cytochrome-c reductase activity<br>( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0008121">https://www.ebi.ac.uk/QuickGO/term/GO:0008121</a> )  |                         |  |                         |
|  | GO - Biological Process |  |                         |

GO:0006122 : mitochondrial electron transport, ubiquinol to cytochrome c

(<https://www.ebi.ac.uk/QuickGO/term/GO:0006122>)

GO - Cellular Component

GO:0016021 : integral component of membrane

(<https://www.ebi.ac.uk/QuickGO/term/GO:0016021>)

GO:0005739 : mitochondrion (<https://www.ebi.ac.uk/QuickGO/term/GO:0005739>)

GO:0005743 : mitochondrial inner membrane

(<https://www.ebi.ac.uk/QuickGO/term/GO:0005743>)

GO:0005751 : mitochondrial respiratory chain complex IV

(<https://www.ebi.ac.uk/QuickGO/term/GO:0005751>)

GO:0005750 : mitochondrial respiratory chain complex III

(<https://www.ebi.ac.uk/QuickGO/term/GO:0005750>)

Mutation #1

Presumptive Null

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

Molecular Type

Coding (<https://www.gephebase.org/search-criteria?/and+Molecular Type=~Coding^#gephebase-summary-title>)

Aberration Type

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

SNP Coding Change

Nonsynonymous

Molecular Details of the Mutation

G126S and I136T mutation both located in the cd1 helix of the Qo pocket. Combination of these mutations gave extreme resistance to bifenthrin.

Experimental Evidence

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

|            | Taxon A | Taxon B | Position |
|------------|---------|---------|----------|
| Codon      | -       | -       | -        |
| Amino-acid | Gly     | Ser     | 126      |

Main Reference

Mitochondrial heteroplasmy and the evolution of insecticide resistance: non-Mendelian inheritance in action. (2008) (<https://pubmed.ncbi.nlm.nih.gov/18408150>)

Authors

Van Leeuwen T; Vanholme B; Van Pottelberge S; Van Nieuwenhuysse P; Nauen R; Tirry L; Denholm I

Abstract

Genes encoded by mitochondrial DNA (mtDNA) exist in large numbers per cell but can be selected very rapidly as a result of unequal partitioning of mtDNA between germ cells during embryogenesis. However, empirical studies of this "bottlenecking" effect are rare because of the apparent scarcity of heteroplasmic individuals possessing more than one mtDNA haplotype. Here, we report an example of insecticide resistance in an arthropod pest (*Tetranychus urticae*) being controlled by mtDNA and on its inheritance in a heteroplasmic mite strain. Resistance to the insecticide bifenthrin is highly correlated with remarkable mutations in cytochrome b, a mitochondrially encoded protein in the respiratory pathway. Four sites in the Q(o) site that are absolutely conserved across fungi, protozoa, plants, and animals are mutated in resistant mite strains. Despite the unusual nature of these mutations, resistant mites showed no fitness costs in the absence of insecticide. Partially resistant strains, consisting of heteroplasmic individuals, transmit their resistant and susceptible haplotypes to progeny in highly variable ratios consistent with a sampling bottleneck of approximately 180 copies. Insecticide selection on heteroplasmic individuals favors those carrying resistant haplotypes at a frequency of 60% or more. This combination of factors enables very rapid evolution and accounts for mutations being fixed in most field-collected resistant strains. The results provide a rare insight into non-Mendelian mechanisms of mitochondrial inheritance and evolution, relevant to anticipating and understanding the development of other mitochondrially encoded adaptations in arthropods. They also provide strong evidence of cytochrome b being the target site for bifenthrin in spider mites.

Additional References

Mutation #2

Presumptive Null

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

Molecular Type

Coding (<https://www.gephebase.org/search-criteria?/and+Molecular Type=~Coding^#gephebase-summary-title>)

Aberration Type

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

SNP Coding Change

Nonsynonymous

Molecular Details of the Mutation

G126S and I136T mutation both located in the cd1 helix of the Qo pocket. Combination of these mutations gave extreme resistance to bifenthrin.

Experimental Evidence

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

|            | Taxon A | Taxon B | Position |
|------------|---------|---------|----------|
| Codon      | -       | -       | -        |
| Amino-acid | Ile     | Thr     | 136      |

Main Reference

Mitochondrial heteroplasmy and the evolution of insecticide resistance: non-Mendelian inheritance in action. (2008) (<https://pubmed.ncbi.nlm.nih.gov/18408150>)

Authors

Genes encoded by mitochondrial DNA (mtDNA) exist in large numbers per cell but can be selected very rapidly as a result of unequal partitioning of mtDNA between germ cells during embryogenesis. However, empirical studies of this "bottlenecking" effect are rare because of the apparent scarcity of heteroplasmic individuals possessing more than one mtDNA haplotype. Here, we report an example of insecticide resistance in an arthropod pest (*Tetranychus urticae*) being controlled by mtDNA and on its inheritance in a heteroplasmic mite strain. Resistance to the insecticide bifenthrin is highly correlated with remarkable mutations in cytochrome b, a mitochondrially encoded protein in the respiratory pathway. Four sites in the Q(o) site that are absolutely conserved across fungi, protozoa, plants, and animals are mutated in resistant mite strains. Despite the unusual nature of these mutations, resistant mites showed no fitness costs in the absence of insecticide. Partially resistant strains, consisting of heteroplasmic individuals, transmit their resistant and susceptible haplotypes to progeny in highly variable ratios consistent with a sampling bottleneck of approximately 180 copies. Insecticide selection on heteroplasmic individuals favors those carrying resistant haplotypes at a frequency of 60% or more. This combination of factors enables very rapid evolution and accounts for mutations being fixed in most field-collected resistant strains. The results provide a rare insight into non-Mendelian mechanisms of mitochondrial inheritance and evolution, relevant to anticipating and understanding the development of other mitochondrially encoded adaptations in arthropods. They also provide strong evidence of cytochrome b being the target site for bifenthrin in spider mites.

Additional References

## RELATED GEPHE

8 (Acetylcholinesterase (Ace-1), Chitin synthase 1 (CHS1), CPR, CYP392A16, CYP392E8, glutamate-gated chloride channel (GluCl), para (kdr), PSST)  
(<https://www.gephebase.org/search-criteria?/or+Taxon ID=^32264^/and+Trait=Xenobiotic resistance/and+groupHaplotypes=true#gephebase-summary-title>)

Related Genes

No matches found.

Related Haplotypes

## EXTERNAL LINKS

## COMMENTS

@MitochondrialGene