

GEPHE SUMMARY

|                                                                                                                                                                                                                       |                |            |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------|--------------|
|                                                                                                                                                                                                                       | Gephebase Gene |            | GepheID      |
| CYP6ER1 ( <a href="https://www.gephebase.org/search-criteria?/and+GeneGephebase=CYP6ER1^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+GeneGephebase=CYP6ER1^#gephebase-summary-title</a> ) |                | GP00002475 |              |
|                                                                                                                                                                                                                       | Entry Status   | Courtier   | Main curator |
| Published                                                                                                                                                                                                             |                |            |              |

PHENOTYPIC CHANGE

|                                                                                                                                                                                                                                                                                                                                     |                             |                                                                                                                                                                                                                                                                                                                           |                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
|                                                                                                                                                                                                                                                                                                                                     | Trait Category              |                                                                                                                                                                                                                                                                                                                           |                             |
| Physiology ( <a href="https://www.gephebase.org/search-criteria?/and+TraitCategory=Physiology^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+TraitCategory=Physiology^#gephebase-summary-title</a> )                                                                                                      |                             | Trait                                                                                                                                                                                                                                                                                                                     |                             |
| Xenobiotic resistance (insecticide; imidacloprid) ( <a href="https://www.gephebase.org/search-criteria?/and+Trait=Xenobiotic+resistance+(insecticide;+imidacloprid)^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Trait=Xenobiotic+resistance+(insecticide;+imidacloprid)^#gephebase-summary-title</a> ) |                             |                                                                                                                                                                                                                                                                                                                           |                             |
|                                                                                                                                                                                                                                                                                                                                     | Trait State in Taxon A      |                                                                                                                                                                                                                                                                                                                           |                             |
| Nilaparvata lugens - sensitive                                                                                                                                                                                                                                                                                                      |                             | Trait State in Taxon B                                                                                                                                                                                                                                                                                                    |                             |
| Nilaparvata lugens - resistant (CYP6ER1vA allele)                                                                                                                                                                                                                                                                                   |                             |                                                                                                                                                                                                                                                                                                                           |                             |
|                                                                                                                                                                                                                                                                                                                                     | Ancestral State             |                                                                                                                                                                                                                                                                                                                           |                             |
| Taxon A                                                                                                                                                                                                                                                                                                                             |                             | Taxonomic Status                                                                                                                                                                                                                                                                                                          |                             |
| Intraspecific ( <a href="https://www.gephebase.org/search-criteria?/and+TaxonomicStatus=Intraspecific^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+TaxonomicStatus=Intraspecific^#gephebase-summary-title</a> )                                                                                         |                             |                                                                                                                                                                                                                                                                                                                           |                             |
|                                                                                                                                                                                                                                                                                                                                     | Taxon A                     |                                                                                                                                                                                                                                                                                                                           | Taxon B                     |
|                                                                                                                                                                                                                                                                                                                                     | Latin Name                  |                                                                                                                                                                                                                                                                                                                           | Latin Name                  |
| Nilaparvata lugens ( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=Nilaparvata+lugens^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=Nilaparvata+lugens^#gephebase-summary-title</a> )                                                                    |                             | Nilaparvata lugens ( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=Nilaparvata+lugens^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=Nilaparvata+lugens^#gephebase-summary-title</a> )                                                          |                             |
|                                                                                                                                                                                                                                                                                                                                     | Common Name                 |                                                                                                                                                                                                                                                                                                                           | Common Name                 |
| brown planthopper                                                                                                                                                                                                                                                                                                                   |                             | brown planthopper                                                                                                                                                                                                                                                                                                         |                             |
|                                                                                                                                                                                                                                                                                                                                     | Synonyms                    |                                                                                                                                                                                                                                                                                                                           | Synonyms                    |
| brown planthopper; Nilaparvata lugens (Stal, 1854); Nalaparvata lugens                                                                                                                                                                                                                                                              |                             | brown planthopper; Nilaparvata lugens (Stal, 1854); Nalaparvata lugens                                                                                                                                                                                                                                                    |                             |
|                                                                                                                                                                                                                                                                                                                                     | Rank                        |                                                                                                                                                                                                                                                                                                                           | Rank                        |
| species                                                                                                                                                                                                                                                                                                                             |                             | species                                                                                                                                                                                                                                                                                                                   |                             |
|                                                                                                                                                                                                                                                                                                                                     | Lineage                     |                                                                                                                                                                                                                                                                                                                           | Lineage                     |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Mandibulata; Pancrustacea; Hexapoda; Insecta; Dicondylia; Pterygota; Neoptera; Paraneoptera; Hemiptera; Auchenorrhyncha; Fulgoromorpha; Fulgoroidea; Delphacidae; Delphacinae; Nilaparvata           |                             | cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Protostomia; Ecdysozoa; Panarthropoda; Arthropoda; Mandibulata; Pancrustacea; Hexapoda; Insecta; Dicondylia; Pterygota; Neoptera; Paraneoptera; Hemiptera; Auchenorrhyncha; Fulgoromorpha; Fulgoroidea; Delphacidae; Delphacinae; Nilaparvata |                             |
|                                                                                                                                                                                                                                                                                                                                     | Parent                      |                                                                                                                                                                                                                                                                                                                           | Parent                      |
| Nilaparvata () - (Rank: genus) ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108930">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108930</a> )                                                                                                                                              |                             | Nilaparvata () - (Rank: genus) ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108930">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108930</a> )                                                                                                                                    |                             |
|                                                                                                                                                                                                                                                                                                                                     | NCBI Taxonomy ID            |                                                                                                                                                                                                                                                                                                                           | NCBI Taxonomy ID            |
| 108931 ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108931">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108931</a> )                                                                                                                                                                      |                             | 108931 ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108931">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=108931</a> )                                                                                                                                                            |                             |
|                                                                                                                                                                                                                                                                                                                                     | is Taxon A an Intraspecies? |                                                                                                                                                                                                                                                                                                                           | is Taxon B an Intraspecies? |
| No                                                                                                                                                                                                                                                                                                                                  |                             | No                                                                                                                                                                                                                                                                                                                        |                             |

GENOTYPIC CHANGE

|                                                                                                                                                                                                                                  |                         |                                                                                                                  |                                                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                  | Generic Gene Name       |                                                                                                                  | UniProtKB Nilaparvata lugens                                                                                                 |
| cyp6er1                                                                                                                                                                                                                          |                         | A0A2I8B6P1 ( <a href="http://www.uniprot.org/uniprot/A0A2I8B6P1">http://www.uniprot.org/uniprot/A0A2I8B6P1</a> ) |                                                                                                                              |
|                                                                                                                                                                                                                                  | Synonyms                |                                                                                                                  | GenebankID or UniProtKB Nilaparvata lugens                                                                                   |
| -                                                                                                                                                                                                                                |                         |                                                                                                                  |                                                                                                                              |
|                                                                                                                                                                                                                                  | String                  |                                                                                                                  | A0A2I8B6P1 ( <a href="https://www.ncbi.nlm.nih.gov/nuccore/A0A2I8B6P1">https://www.ncbi.nlm.nih.gov/nuccore/A0A2I8B6P1</a> ) |
| -                                                                                                                                                                                                                                |                         |                                                                                                                  |                                                                                                                              |
|                                                                                                                                                                                                                                  | Sequence Similarities   |                                                                                                                  |                                                                                                                              |
| Belongs to the cytochrome P450 family.                                                                                                                                                                                           |                         |                                                                                                                  |                                                                                                                              |
|                                                                                                                                                                                                                                  | GO - Molecular Function |                                                                                                                  |                                                                                                                              |
| GO:0020037 : heme binding ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0020037">https://www.ebi.ac.uk/QuickGO/term/GO:0020037</a> )                                                                                          |                         |                                                                                                                  |                                                                                                                              |
| GO:0005506 : iron ion binding ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0005506">https://www.ebi.ac.uk/QuickGO/term/GO:0005506</a> )                                                                                      |                         |                                                                                                                  |                                                                                                                              |
| GO:0004497 : monooxygenase activity ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0004497">https://www.ebi.ac.uk/QuickGO/term/GO:0004497</a> )                                                                                |                         |                                                                                                                  |                                                                                                                              |
| GO:0016705 : oxidoreductase activity, acting on paired donors, with incorporation or reduction of molecular oxygen ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0016705">https://www.ebi.ac.uk/QuickGO/term/GO:0016705</a> ) |                         |                                                                                                                  |                                                                                                                              |
|                                                                                                                                                                                                                                  | GO - Biological Process |                                                                                                                  |                                                                                                                              |
| -                                                                                                                                                                                                                                |                         |                                                                                                                  |                                                                                                                              |

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

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

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

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

A significant (up to 9.5-fold) increase in expression driven by the promoter of CYP6ER1vA was observed in comparison to all other promoter variants. This suggests that cis-acting elements in the region upstream of CYP6ER1vA are responsible for the high expression of this variant in BPH populations across Southeast Asia.

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

Neofunctionalization of Duplicated P450 Genes Drives the Evolution of Insecticide Resistance in the Brown Planthopper. (2018) (<https://pubmed.ncbi.nlm.nih.gov/29337073>)

Zimmer CT; Garrood WT; Singh KS; Randall E; Lueke B; Gutbrod O; Matthiesen S; Kohler M; Nauen R; Davies TGE; Bass C

Gene duplication is a major source of genetic variation that has been shown to underpin the evolution of a wide range of adaptive traits [1, 2]. For example, duplication or amplification of genes encoding detoxification enzymes has been shown to play an important role in the evolution of insecticide resistance [3-5]. In this context, gene duplication performs an adaptive function as a result of its effects on gene dosage and not as a source of functional novelty [3, 6-8]. Here, we show that duplication and neofunctionalization of a cytochrome P450, CYP6ER1, led to the evolution of insecticide resistance in the brown planthopper. Considerable genetic variation was observed in the coding sequence of CYP6ER1 in populations of brown planthopper collected from across Asia, but just two sequence variants are highly overexpressed in resistant strains and metabolize imidacloprid. Both variants are characterized by profound amino-acid alterations in substrate recognition sites, and the introduction of these mutations into a susceptible P450 sequence is sufficient to confer resistance. CYP6ER1 is duplicated in resistant strains with individuals carrying paralogs with and without the gain-of-function mutations. Despite numerical parity in the genome, the susceptible and mutant copies exhibit marked asymmetry in their expression with the resistant paralogs overexpressed. In the primary resistance-conferring CYP6ER1 variant, this results from an extended region of novel sequence upstream of the gene that provides enhanced expression. Our findings illustrate the versatility of gene duplication in providing opportunities for functional and regulatory innovation during the evolution of an adaptive trait.

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## RELATED GEPHE

4 (Acetylcholinesterase (Ace-1), CYP6AY1, esterase NI-EST1, GST) (<https://www.gephebase.org/search-criteria?/or+Taxon ID=^108931^/and+Trait=Xenobiotic resistance/and+groupHaplotypes=true#gephebase-summary-title>)

3 (<https://www.gephebase.org/search-criteria?/or+Gene Gephebase=^CYP6ER1^/and+Taxon ID=^108931^/or+Gene Gephebase=^CYP6ER1^/and+Taxon ID=^108931^#gephebase-summary-title>)

## EXTERNAL LINKS

## COMMENTS