

GEPHE SUMMARY

|   |   |                                   |                                    |
|---|---|-----------------------------------|------------------------------------|
| <p>pepsinogen A3 (<a href="https://www.gephebase.org/search-criteria?/and+Gene+Gephebase=~pepsinogen+A3~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Gene+Gephebase=~pepsinogen+A3~#gephebase-summary-title</a>)</p> <p>Published</p> | <p>Gephebase Gene</p> <p>Entry Status</p> | <p>GP00001932</p> <p>Courtier</p> | <p>GepheID</p> <p>Main curator</p> |
|---|---|-----------------------------------|------------------------------------|

PHENOTYPIC CHANGE

|   |   |
|---|---|
| <p>Physiology (<a href="https://www.gephebase.org/search-criteria?/and+Trait+Category=~Physiology~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Trait+Category=~Physiology~#gephebase-summary-title</a>)</p> <p>Digestion (absence of stomach) (<a href="https://www.gephebase.org/search-criteria?/and+Trait=~Digestion+(absence+of+stomach)~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Trait=~Digestion+(absence+of+stomach)~#gephebase-summary-title</a>)</p> <p>presence of stomach and gastric acid production</p> <p>loss of stomach and no gastric acid production</p> <p>Taxon A</p> <p>Intergeneric or Higher (<a href="https://www.gephebase.org/search-criteria?/and+Taxonomic+Status=~Intergeneric+or+Higher~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxonomic+Status=~Intergeneric+or+Higher~#gephebase-summary-title</a>)</p> | <p>Trait Category</p> <p>Trait</p> <p>Trait State in Taxon A</p> <p>Trait State in Taxon B</p> <p>Ancestral State</p> <p>Taxonomic Status</p> |
|---|---|

|   |                                    |
|---|------------------------------------|
| <b>Taxon A #1</b>   | <b>Latin Name</b>                  |
| Oreochromis niloticus<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Oreochromis+niloticus~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Oreochromis+niloticus~#gephebase-summary-title</a> )  |                                    |
| Nile tilapia  | <b>Common Name</b>                 |
| Oreochromis nilotica; Tilapia nilotica; Nile tilapia; Oreochromis niloticus (Linnaeus, 1758)  | <b>Synonyms</b>                    |
| species   | <b>Rank</b>                        |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Deuterostomia; Chordata; Craniata; Vertebrata; Gnathostomata; Teleostomi; Euteleostomi; Actinopterygii; Actinopteri; Neopterygii; Teleostei; Osteoglossocephalai; Clupeocephala; Euteleostomorpha; Neoteleostei; Eurypterygia; Ctenosquamata; Acanthomorphata; Euacanthomorphacea; Percomorphaceae; Ovalentaria; Cichlomorphae; Cichliformes; Cichlidae; African cichlids; Pseudocrenilabrinae; Oreochromini; Oreochromis | <b>Lineage</b>                     |
| Oreochromis () - (Rank: genus)<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=8139">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=8139</a> )   | <b>Parent</b>                      |
| 8128<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=8128">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=8128</a> )   | <b>NCBI Taxonomy ID</b>            |
| No  | <b>is Taxon A an Infrappecies?</b> |

|  |                                    |
|--|------------------------------------|
| <b>Taxon B #1</b>  | <b>Latin Name</b>                  |
| Takifugu rubripes<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Takifugu+rubripes~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Takifugu+rubripes~#gephebase-summary-title</a> )   |                                    |
| torafugu   | <b>Common Name</b>                 |
| Fugu rubripes; Sphaeroides rubripes; Tetraodon rubripes; torafugu; tiger puffer; Takifugu rubripes (Temminck & Schlegel, 1850)   | <b>Synonyms</b>                    |
| species  | <b>Rank</b>                        |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Deuterostomia; Chordata; Craniata; Vertebrata; Gnathostomata; Teleostomi; Euteleostomi; Actinopterygii; Actinopteri; Neopterygii; Teleostei; Osteoglossocephalai; Clupeocephala; Euteleostomorpha; Neoteleostei; Eurypterygia; Ctenosquamata; Acanthomorphata; Euacanthomorphacea; Percomorphaceae; Eupercaria; Tetraodontiformes; Tetraodontoidei; Tetradontoidea; Tetraodontidae; Takifugu | <b>Lineage</b>                     |
| Takifugu () - (Rank: genus)<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=31032">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=31032</a> )   | <b>Parent</b>                      |
| 31033<br>( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=31033">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=31033</a> )   | <b>NCBI Taxonomy ID</b>            |
| No   | <b>is Taxon B an Infrappecies?</b> |

|   |                    |
|---|--------------------|
| <b>Taxon A #2</b>   | <b>Latin Name</b>  |
| Gasterosteus aculeatus<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Gasterosteus+aculeatus~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Gasterosteus+aculeatus~#gephebase-summary-title</a> )   |                    |
| three-spined stickleback  | <b>Common Name</b> |
| three-spined stickleback; three spined stickleback; Gasterosteus aculeatus Linnaeus, 1758   | <b>Synonyms</b>    |
| species   | <b>Rank</b>        |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Deuterostomia; Chordata; Craniata; Vertebrata; Gnathostomata; Teleostomi; Euteleostomi; Actinopterygii; Actinopteri; Neopterygii; Teleostei; Osteoglossocephalai; Clupeocephala; Euteleostomorpha; Neoteleostei; Eurypterygia; Ctenosquamata; Acanthomorphata; Euacanthomorphacea; Percomorphaceae; | <b>Lineage</b>     |

|   |                    |
|---|--------------------|
| <b>Taxon B #2</b>   | <b>Latin Name</b>  |
| Tetraodon nigroviridis<br>( <a href="https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Tetraodon+nigroviridis~#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Taxon+and+Synonyms=~Tetraodon+nigroviridis~#gephebase-summary-title</a> )   |                    |
| spotted green pufferfish  | <b>Common Name</b> |
| spotted green pufferfish; Tetraodon nigroviridis Marion de Proce, 1822  | <b>Synonyms</b>    |
| species   | <b>Rank</b>        |
| cellular organisms; Eukaryota; Opisthokonta; Metazoa; Eumetazoa; Bilateria; Deuterostomia; Chordata; Craniata; Vertebrata; Gnathostomata; Teleostomi; Euteleostomi; Actinopterygii; Actinopteri; Neopterygii; Teleostei; Osteoglossocephalai; Clupeocephala; Euteleostomorpha; Neoteleostei; Eurypterygia; Ctenosquamata; Acanthomorphata; Euacanthomorphacea; Percomorphaceae; Eupercaria; Tetraodontiformes; Tetraodontoidei; Tetradontoidea; Tetraodontidae; | <b>Lineage</b>     |

|   |                             |
|---|-----------------------------|
| Eupercaria; Perciformes; Cottioidei; Gasterosteales; Gasterosteidae; Gasterosteus   | Parent                      |
| Gasterosteus () - (Rank: genus)   |                             |
| ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=69292">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=69292</a> ) | NCBI Taxonomy ID            |
| 69293   |                             |
| ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=69293">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=69293</a> ) | is Taxon A an Infrappecies? |
| No  |                             |

|   |                             |
|---|-----------------------------|
| Tetraodon   | Parent                      |
| Tetraodon () - (Rank: genus)  |                             |
| ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=47144">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=47144</a> ) | NCBI Taxonomy ID            |
| 99883   |                             |
| ( <a href="https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=99883">https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=99883</a> ) | is Taxon B an Infrappecies? |
| No  |                             |

## GENOTYPIC CHANGE

|  |                         |  |                                   |
|--|-------------------------|--|-----------------------------------|
| PGA4   | Generic Gene Name       | P0DJD7 ( <a href="http://www.uniprot.org/uniprot/P0DJD7">http://www.uniprot.org/uniprot/P0DJD7</a> ) | UniProtKB Homo sapiens            |
| -  | Synonyms                | 0  | GenebankID or UniProtKB           |
| 9606.ENSPO0000367391   | String                  |  |                                   |
| ( <a href="http://string-db.org/newstring.cgi/show_network_section.pl?identifier=9606.ENSPO0000367391">http://string-db.org/newstring.cgi/show_network_section.pl?identifier=9606.ENSPO0000367391</a> )  |                         |  |                                   |
| 9606.ENSPO0000367391   | Sequence Similarities   |  |                                   |
| Belongs to the peptidase A1 family.  |                         |  |                                   |
| GO:0004190 : aspartic-type endopeptidase activity  | GO - Molecular Function |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0004190">https://www.ebi.ac.uk/QuickGO/term/GO:0004190</a> )  |                         |  |                                   |
| GO:0006508 : proteolysis   | GO - Biological Process |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0006508">https://www.ebi.ac.uk/QuickGO/term/GO:0006508</a> )  |                         |  |                                   |
| GO:0044267 : cellular protein metabolic process  |                         |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0044267">https://www.ebi.ac.uk/QuickGO/term/GO:0044267</a> )  |                         |  |                                   |
| GO:0007586 : digestion   |                         |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0007586">https://www.ebi.ac.uk/QuickGO/term/GO:0007586</a> )  |                         |  |                                   |
| GO:0030163 : protein catabolic process   |                         |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0030163">https://www.ebi.ac.uk/QuickGO/term/GO:0030163</a> )  |                         |  |                                   |
| GO:0070062 : extracellular exosome   | GO - Cellular Component |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0070062">https://www.ebi.ac.uk/QuickGO/term/GO:0070062</a> )  |                         |  |                                   |
| GO:0097486 : multivesicular body lumen   |                         |  |                                   |
| ( <a href="https://www.ebi.ac.uk/QuickGO/term/GO:0097486">https://www.ebi.ac.uk/QuickGO/term/GO:0097486</a> )  |                         |  |                                   |
| Yes ( <a href="https://www.gephebase.org/search-criteria?/and+Presumptive Null=^Yes^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Presumptive Null=^Yes^#gephebase-summary-title</a> )  |                         |  | Presumptive Null                  |
| Gene Loss ( <a href="https://www.gephebase.org/search-criteria?/and+Molecular Type=^Gene Loss^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Molecular Type=^Gene Loss^#gephebase-summary-title</a> )  |                         |  | Molecular Type                    |
| Deletion ( <a href="https://www.gephebase.org/search-criteria?/and+Aberration Type=^Deletion^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Aberration Type=^Deletion^#gephebase-summary-title</a> )   |                         |  | Aberration Type                   |
| -  |                         |  | Deletion Size                     |
| Absence of the gene in the genome sequence - high synteny  |                         |  | Molecular Details of the Mutation |
| Candidate Gene ( <a href="https://www.gephebase.org/search-criteria?/and+Experimental Evidence=^Candidate Gene^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/and+Experimental Evidence=^Candidate Gene^#gephebase-summary-title</a> )   |                         |  | Experimental Evidence             |
| Recurrent gene loss correlates with the evolution of stomach phenotypes in gnathostome history. (2014) ( <a href="https://pubmed.ncbi.nlm.nih.gov/24307675">https://pubmed.ncbi.nlm.nih.gov/24307675</a> )   |                         |  | Main Reference                    |
| Castro LF; Gonsalves O; Mazan S; Tay BH; Venkatesh B; Wilson JM   |                         |  | Authors                           |
| The stomach, a hallmark of gnathostome evolution, represents a unique anatomical innovation characterized by the presence of acid- and pepsin-secreting glands. However, the occurrence of these glands in gnathostome species is not universal; in the nineteenth century the French zoologist Cuvier first noted that some teleosts lacked a stomach. Strikingly, Holocephali (chimaeras), dipnoids (lungfish) and monotremes (egg-laying mammals) also lack acid secretion and a gastric cellular phenotype. Here, we test the hypothesis that loss of the gastric phenotype is correlated with the loss of key gastric genes. We investigated species from all the main gnathostome lineages and show the specific contribution of gene loss to the widespread distribution of the agastric condition. We establish that the stomach loss correlates with the persistent and complete absence of the gastric function gene kit-H(+)/K(+)-ATPase (Atp4A and Atp4B) and pepsinogens (Pga, Pgc, Cym)--in the analysed species. We also find that in gastric species the pepsinogen gene complement varies significantly (e.g. two to four in teleosts and tens in some mammals) with multiple events of pseudogenization identified in various lineages. We propose that relaxation of purifying selection in pepsinogen genes and possibly proton pump genes in response to dietary changes led to the numerous independent events of stomach loss in gnathostome history. Significantly, the absence of the gastric genes predicts that reinvention of the stomach in agastric lineages would be highly improbable, in line with Dollo's principle. |                         |  | Abstract                          |
|  |                         |  | Additional References             |

## RELATED GEPHE

|   |                    |
|---|--------------------|
| 4 (ATP4A, ATP4B, pepsinogen A1, pepsinogen A2) ( <a href="https://www.gephebase.org/search-criteria?/or+Taxon ID=^8128^/and+Trait=Digestion/or+Taxon ID=^69293^/and+Trait=Digestion/or+Taxon ID=^31033^/and+Trait=Digestion/or+Taxon ID=^99883^/and+Trait=Digestion/and+groupHaplotypes=true#gephebase-summary-title">https://www.gephebase.org/search-criteria?/or+Taxon ID=^8128^/and+Trait=Digestion/or+Taxon ID=^69293^/and+Trait=Digestion/or+Taxon ID=^31033^/and+Trait=Digestion/or+Taxon ID=^99883^/and+Trait=Digestion/and+groupHaplotypes=true#gephebase-summary-title</a> )                          | Related Genes      |
| 2 ( <a href="https://www.gephebase.org/search-criteria?/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^8128^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^69293^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^31033^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^99883^#gephebase-summary-title">https://www.gephebase.org/search-criteria?/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^8128^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^69293^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^31033^/or+Gene Gephebase=^pepsinogen A3^/and+Taxon ID=^99883^#gephebase-summary-title</a> ) | Related Haplotypes |

## EXTERNAL LINKS

## COMMENTS

There are three pepsinogen A genes in teleost fishes - their nomenclature and phylogenetic relationships are different from Mammals pepsinogen genes - Not clear if this is independent evolution in *Tetraodon nigroviridis* and in *Takifugu rubripes* (no detailed phylogenetic tree in the paper)