

Review

Transcriptomic Analysis of Nervous Necrosis Virus Interactions with Fish Hosts

Dimitra K. Toubanaki ^{1,*}, Antonia Efstathiou ¹ and Evdokia Karagouni ^{1,*}

Supplementary Material

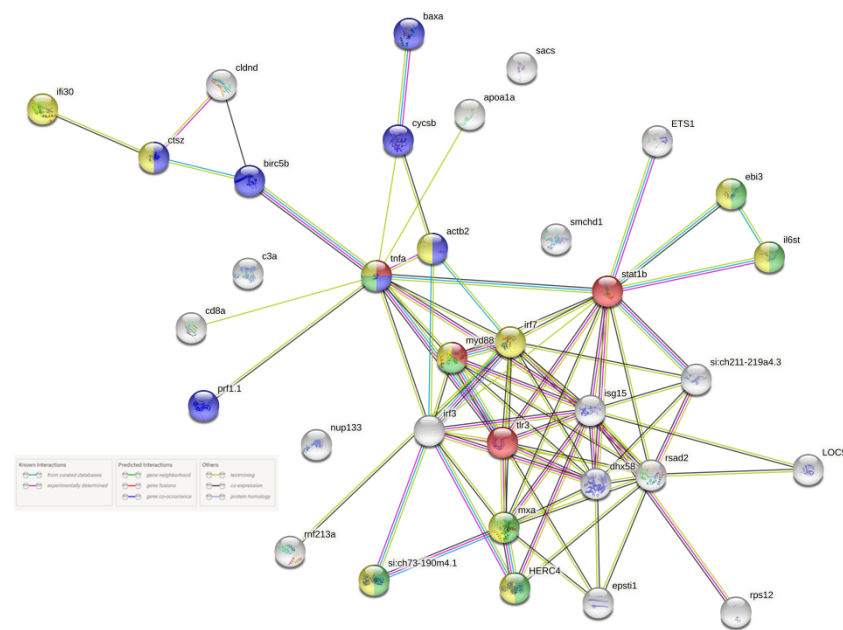


Figure S1: Protein-protein interaction (PPI) networks for the most frequently differentially expressed proteins found in different teleost fishes during NNV infection including an additional enriched biological process (Immune system). This is retrieved via API access to the STRING database (<https://string-db.org>) and was performed based on the Danio rerio protein database. Of the 65 proteins, 34 proteins are illustrated as the rest were not found in the Search Tool for the Retrieval of Interacting Genes/Proteins database of the STRING database. Each node represents a differentially expressed protein. Node colors illustrate a protein's involvement in the three significantly enriched biological processes identified by Biological Networks Gene Ontology (Red nodes: Toll-like receptor signalling pathway. Blue nodes: apoptosis. Green nodes: cytokine signalling in immune system. Yellow nodes: Immune system). Gray nodes are not associated with any of the significantly enriched biological processes. The edges represent protein-protein interactions, and the nature of the protein-protein interactions are color-coded as indicated in the figure.

Table S3. Abbreviations

ACOT8	Acyl-CoA Thioesterase 8
ACNNV	Atlantic Cod Nervous Necrosis Virus
ACTB	Actin Beta

ACTH	Adrenocorticotrophic Hormone
ADK1-2	Adenylate Kinase 1- 2
AIP	Aryl Hydrocarbon Receptor-Interacting Protein
AMPs	Antimicrobial Peptide
ANO10	Anoctamin-10
ANXA3	Annexin A3
Apaf-1	Apoptotic Protease Activating Factor 1
ApoA-I	Apolipoprotein A1
AP2a1	Adaptor Related Protein Complex 2 Subunit Alpha 1
ATF6	Activating Transcription Factor 6
ATG4	Autophagy-Regulating Protease 4
ATG9L	Autophagy-Related Protein 9
ATG16	Autophagy Related Protein 16
ATP2A1	Sarcoplasmic Endoplasmic Reticulum Calcium Atpase 1-Like
AURKB	Serine/Threonine-Protein Phosphatase 5 Or Aurora Kinase B
BAX	Bcl2 Associated X, Apoptosis Regulator
BD	B-Defensin
BFNNV	Barfin Flounder Nervous Necrosis Virus
Bid	Bh3 Interacting Domain Death Agonist
BiP	Saxitoxin Binding Protein/Immunoglobulin Heavy-Chain Binding Protein
BIRC5	Baculoviral Iap Repeat Containing 5
BLAST	Basic Local Alignment Search Tool
BNIP3	BCL2/Adenovirus E1B 19 Kda Protein
BP	Biological Process
B4GALT1	Beta-1,4-Galactosyltransferase 1
BTK	Tyrosine-Protein Kinase
C1	Complement Component 1

C1QT1	Complement C1q Tumour Necrosis Factor-Related Protein 1
C3	Complement Component 3
C3aR	C3a Anaphylatoxin Chemotactic Receptor
C5	Complement Component 5
C7	Complement Component 7
C8	Complement Component 8
C9	Complement Component 9
CARD	Caspase Recruitment Domain
CAMs	Cell Adhesion Molecules
CASP3	Caspase 3
CASP6	Caspase 6
CASP7	Caspase 7
CASP8	Caspase 8
CASP9	Caspase 9
CASP10	Caspase 10
CBLN1	Cerebellin 1
CC	Cellular Component
CCK	Cholecystokinin
CCL2	C-C Motif Chemokine Ligand 2
CCL3	C-C Motif Chemokine Ligand 3
CCL4	C-C Motif Chemokine Ligand 4
CCL19	Chemokine (C-C Motif) Ligand 19
CCL19L1	Chemokine (C-C Motif) Ligand 19 L1
CCL20	C-C Motif Chemokine Ligand 20
CCL25	C-C Motif Chemokine Ligand 25
CCR5	C-C Chemokine Receptor Type 5
CCR9	C-C Motif Chemokine Receptor 9

CDD	Cytidine Deaminase
cDNA	Complementary DNA
CD3E	Cluster Of Differentiation 3 Epsilon
CD8A	Cluster Of Differentiation 8 Alpha
CD3	Cluster Of Differentiation 3
CD4	Cluster Of Differentiation 4
CD8	Cluster Of Differentiation 8
CD28	Cluster Of Differentiation 28
CD53	Leukocyte Surface Antigen
CD125	Cluster Of Differentiation 125
CD209	Cluster Of Differentiation 209
CEBPA	Ccaat Enhancer Binding Protein Alpha
CEBPD	Ccaat Enhancer Binding Protein Delta
CFHR3	Complement Factor H-Related Protein 3 Precursor)
CHMP2a	Charged Multivesicular Body Protein 2a
CHOP	C/EBP Homologous Protein
CH25H	Cholesterol 25-Hydroxylase
circRNA	Circular RNA
CLEC4M	C-Type Lectin Domain Family 4 Member M
CLEC10A	C-Type Lectin Domain Containing 10a
CMC	Cell-Mediated Cytotoxic
CNS	Central Nervous System
COGs	Clusters Of Orthologous Groups
COL1A2	Collagen Type I Alpha 2 Chain
COX-2	Cyclooxygenase 2
CP	Ceruloplasmin
CTL	Cytotoxic T Lymphocytes

CUL1a	Cullin 1a
CXCL6	C-X-C Motif Chemokine Ligand 6
CXCL8	C-X-C Motif Chemokine Ligand 8
CXCL9	C-X-C Motif Chemokine Ligand 9
CXCL10	C-X-C Motif Chemokine Ligand 10
CXCL12	C-X-C Motif Chemokine Ligand 12
CXCL13	C-X-C Motif Chemokine Ligand 13
CXCL14	C-X-C Motif Chemokine Ligand 14
CXCR1	C-X-C Motif Chemokine Receptor 1
CXCR3	C-X-C Motif Chemokine Receptor 3
CXCR4	C-X-C Motif Chemokine Receptor 4
CXR1	C-X-C Motif Chemokine Receptor 1
CYBA	Cytochrome B-245 Light Chain
CYP2P3	Cytochrome P450 2P3
CYP11A1	Cholesterol Side-Chain Cleavage Enzyme
CYP11b1	Cytochrome P450 11b
CYP17a1	Cytochrome P450 17a1
CYP21A	Steroid 21-Hydroxylase
CytC	Cytochrome C
DAVID	Database For Annotation, Visualization And Integrated Discovery
DC	Dendritic Cell
DEGs	Differentially Expressed Genes
DHX58	Laboratory Of Genetics And Physiology 2
DIABLO	Apoptotic Protease Activating Factor 1
DLB-1	D. Labrax Brain Cell Line
DNA	Deoxyribonucleic Acid
DPCP1	Mrna-Decapping Enzyme 1A

EBI3	Epstein-Barr Virus Induced 3
ECM	Extracellular Matrix
EIF2Ak2	Eukaryotic Translation Initiation Factor 2 Alpha Kinase 2
EndoG	Endonuclease G
EPHX2	Epoxide Hydrolase 2
Epi-1	Epinecidin-1
EPSTI1	Epithelial Stromal Interaction 1
ER	Endoplasmic Reticulum
ERAP2	Endoplasmic Reticulum Aminopeptidase 2
ERGIC-53	ER-Golgi Intermediate Compartment 53 Kda Protein
ERO1a	Endoplasmic Reticulum Oxidoreductase (Ero) 1-Like Protein Alpha
EWSR1	Ewing Sarcoma Protein (EWS) RNA Binding Protein 1
FAO	Food And Agriculture Organization
Fas	Fas Cell Surface Death Receptor
FBX118	F-Box And Leucine Rich Repeat Protein 18
FKBP4	Peptidyl-Prolyl Cis-Trans Isomerase (FKBP) Prolyl Isomerase 4
FUCL4	Fucolectin
FYB	Fyn Binding Protein 1
GABA	Gamma-Aminobutyric Acid
GADD34	Growth Arrest And DNA Damage-Inducible Protein
GALT	Gut-Associated Lymphoid Tissue
GEO	Gene Expression Omnibus
GF-1	Grouper Fin Cell Line
GH	Growth Hormone
GiALT	Gill-Associated Lymphoid Tissue
GIG1	Protein GIGAS CELL1
GILT	Gamma-Interferon-Inducible Lysosomal Thiol Reductase

GK	Grouper Kidney Cells
GLHA	Gonadotropin
GLUD1	Glutamate Dehydrogenase 1
GNG3	G Protein Subunit Gamma 3
GO	Gene Ontology
GPR21	G Protein-Coupled Receptor 21
GRP78	Glucose-Regulated Protein 78
GSEA	Gene Set Enrichment Analysis
GSTK1	Glutathione S-Transferase Kappa 1
GVINP1	Gtpase, Very Large Interferon Inducible Pseudogene 1
HECTD2	Hect Domain E3 Ubiquitin Protein Ligase 2
HERC4	Hect And Rld Domain Containing E3 Ubiquitin Protein Ligase 4
HERC5	Hect And Rld Domain Containing E3 Ubiquitin Protein Ligase 5
HK	Head Kidney
HKLs	Head-Kidney Leukocytes
HLA-A	Human Leukocyte Antigen A
HMOX1	Heme Oxygenase 1
HPI	Hypothalamic-Pituitary-Interrenal
HSC70	Heat Shock Cognate 71 Kda Protein
HSP	Heat Shock Protein
HSPA5	Heat Shock Protein 5
HSPA9	Heat Shock Protein 9
HSP30	Heat Shock Protein 30
HSP70	Heat Shock Protein 70
HSP90	Heat Shock Protein 90
HYOU1	Hypoxia Up-Regulated Protein 1
IFI35	Interferon Inducible Protein 35

IFI44	Interferon Induced Protein 44
IFI56	Interferon Induced Protein 56
IFI27L2	Interferon Alpha Inducible Protein 27 Like 2
IFIH1	Interferon Induced With Helicase C Domain 1
IFIM	Interferon-Induced Transmembrane Protein
IFIT-1	Interferon Induced Protein With Tetratricopeptide Repeats 1
IFIT5	Interferon Induced Protein With Tetratricopeptide Repeats 5
IFN	Interferon
IFN-I	Interferon-I
IFNPHI1	Interferon Phi 1
IFNPHI3	Interferon Phi 3
IgA	Immunoglobulin A
IgD	Immunoglobulin D
IgHM	Immunoglobulin M Heavy Chain
IgM	Immunoglobulin M
IgT	Immunoglobulin T
IgZ	Immunoglobulin Z
IL-1	Interleukin 1
IL-1b	Interleukin 1 Beta
IL-2	Interleukin 2
IL-8	Interleukin 8
IL-10	Interleukin 10
IL-11	Interleukin 11
IL-12	Interleukin 12
IL-15	Interleukin 15
IL-17a	Interleukin 15 Alpha
IL5Rα	Interleukin-5 Receptor Subunit Alpha

IL6st	Interleukin 6 Cytokine Family Signal Transducer
IL12a	Interleukin 12 Alpha
IL12b	Interleukin 12 Beta
IL18b	Interleukin 18 Beta
ILF3/NF90	Interleukin Enhancer Binding Factor 3
IM	Intramuscular Injection
IP3R	Inositol 1,4,5-Trisphosphate Receptor
IRAK1	Interleukin 1 Receptor Associated Kinase 1
IRE1	Inositol-Requiring Enzyme 1
IRF	Interferon Regulatory Factor
IRF3	Interferon Regulatory Factor 3
IRF5	Interferon Regulatory Factor 5
IRF7	Interferon Regulatory Factor 7
IPA	Ingenuity Pathway Analysis
ISG	Interferon Stimulated Gene
ISG12	Interferon-Stimulated Gene 12
ISG15	Interferon-Stimulated Gene 15
ITGA2	Integrin Subunit Alpha 2
ITK	Tyrosine-Protein Kinase
ITGA6	Integrin Subunit Alpha 6
JAK1	Janus Kinase 1
JAK-STAT	Janus Kinases - Signal Transducer And Activator Of Transcription Proteins
KEGG	Kyoto Encyclopedia Of Genes And Genomes
KSNV	Korean Shellfish Nervous Necrosis Virus
LAG3	Lymphocyte Activating 3
LAMA5	Laminin Subunit Alpha 5
LAMB2	Laminin Subunit Beta 2

LATS2	Large Tumor Suppressor Kinase 2
LC3	Microtubule-Associated Protein 1A/1B-Light Chain 3
LCK	Lymphocyte-Specific Protein Tyrosine Kinase
LECT2	Leukocyte Cell Derived Chemotaxin 2
LGALS3	Galectin 3
LGALS9	Galectin 9
LGP2	Laboratory Of Genetics And Physiology 2
LJB	Lateolabrax Japonicas Brain Cells
LITAF	Lipopolysaccharide Induced Tnf Factor
LMAN1	Lectin Mannose Binding 1
lncRNA	Long Non-Coding RNA
LTPs	Lipid Transfer Proteins
MACPF	Membrane Attack Complex/Perforin
MAGEL2	Melanoma Antigen Gene (Mage) Family Member L2
MALT	Mucosal-Associated Lymphoid Tissues
MAPK	Mitogen-Activated Protein Kinase
MAP6	Microtubule Associated Protein 6
MBL	Mannose-Binding Lectin
MDA5	Melanoma Differentiation-Associated 5 Gene
MDM2	Mdm2 Proto-Oncogene
MDM4	Mdm4 Regulator Of P53
MF	Molecular Function
MGEA5	Meningioma Expressed Antigen 5
MHC	Major Histocompatibility Complex
MHC-I	Major Histocompatibility Complex I
MHC-II	Major Histocompatibility Complex II
miRNA	Microrna

MLC2	Myosin Light Chain 2
MLC3	Myosin Light Chain 3
MR1	Major Histocompatibility Complex, Class I-Related
mRNA	Messenger RNA
Mt	Million Tons
MTUB	Tubulin/Microtubule
mut	Mutant Strain
Mx	Myxovirus Resistance Protein
MxA	Myxovirus Resistance Protein 1
MxB	Myxovirus Resistance Protein B
MxC	Myxovirus (Influenza Virus) Resistance C
MyBP-H	H-Like Myosin Binding Protein
Myd88	Myeloid Differentiation Primary Response Gene
NADPH	Nicotinamide Adenine Dinucleotide Phosphate
NCBI	National Center For Biotechnology Information
NCCRP-1	Nonspecific Cytotoxic Cell Receptor Protein-1
NCF2	Neutrophil Cytosol Factor 2-Like
ncRNA	Non-Coding RNA
NF-κB	Nuclear Factor Kappa-Light-Chain-Enhancer Of Activated B Cells
NGS	Next Generation Sequencing
NILT	Novel Ig-Liketype Receptor
NITR	Novel Immune-Type Receptor
NKTR	Natural Killer Cell Triggering Receptor
NKTRP	Natural Killer Tumour Recognition Protein
NLR	Nucleotide-Binding Oligomerization Domain (NOD)-Like Receptor
NLRC3	NLR Family CARD Domain Containing 3
NLRX1	Nucleotide-Binding Oligomerization Domain, Leucine Rich Repeat Containing X1

NMDE2	Glutamate Receptor Ionotropic
NMI	N-Myc Interactor
NNV	Nervous Necrosis Virus
NOS1	Nitric Oxide Synthase 1
NR	NCBI Non-Redundant Protein
NT	NCBI Nucleotide Sequences
NPTN	Neuroplastin
NUP133	Nucleoporin 133
ORA	Over Representation Analysis
OSBP1	Oxysterol-Binding Protein 1
PARP14	Poly(Adp-Ribose) Polymerase Family Member 14
PAST-1	Putative Achaete Scute Target 1
PDIA4	Protein Disulfide-Isomerase A4
PD-L1	Programmed Death-Ligand 1
PERK	PKR-Like ER Kinase
PEX3	Peroxisomal Biogenesis Factor 3
PEX11	Peroxisomal Biogenesis Factor 11
PEX26	Peroxisomal Biogenesis Factor 26
PKR	Protein Kinase R
PKZ	Z-DNA Binding Protein Kinase
PI3K-Akt	Phosphatidylinositol-3-Kinase/ Protein Kinase B (Akt)
PIK3R1	Phosphoinositide-3-Kinase Regulatory Subunit 1
piRNA	Piwi-Interacting RNA
POMC	Pro-Opiomelanocortin
PPAR	Peroxisome Proliferator-Activated Receptor
Prf1	Perforin 1
PRISMA	Preferred Reporting Items For The Systematic Reviews And Meta-Analyses

PRL	Prolactin
PRRs	Pattern Recognition Receptors
PTGR1	Prostaglandin Reductase 1
PTGER4	Prostaglandin E Receptor 4
PTGES3A	Prostaglandin E Synthase 3 (Cytosolic)
PTX4	Pentraxin 4
PVALB	Parvalbumin
PV1	Parvalbumin 1
PV2	Parvalbumin 2
QORX	Quinone Oxidoreductase Pig3
qPCR	Quantitative PCR
RAB10	Ras-Related Gtp-Binding Protein
RAB11A	Ras-Related Protein Rab-11a
RC3H2	Ring Finger And Cch-Type Domains 2
RdRp	RNA Dependent RNA Polymerase
RDH13	Retinol Dehydrogenase 13
RGNNV	Red-Spotted Grouper Nervous Necrosis Virus
RGS6	G-Protein Signalling 6-Like
RhoG1	Rho-Related GTP-Binding Protein 1
RIG1	Retinoic Acid-Inducible Gene-I
RLR	Retinoic Acid-Inducible Gene-I (RIG1)-Like Receptors
RNA	Ribonucleic Acid
RNA-seq	RNA Sequencing
RNF213	Ring Finger Protein 213
ROS	Reactive Oxygen Species
RPS12	Ribosomal Protein S12
RSAD2	Radical S-Adenosyl Methionin Domain-Containing Protein 2

RTP3	Receptor Transporter Protein 3
SAA	Serum Amyloid A
SACS	Sacsin Molecular Chaperone
SALT	Skin-Associated Lymphoid Tissue
SB	Asian Sea Bass Epithelial Cells
SEMA4B	Semaphorin 4B
SERCA1	Sarcoplasmic Endoplasmic Reticulum Calcium Atpase 1-Like
SF3B1	Splicing Factor 3b Subunit 1
SJNNV	Striped Jack Nervous Necrosis Virus
siRNA	Small Interfering RNA
SL	Somatolactin
SMCHD1	Structural Maintenance Of Chromosomes Flexible Hinge Domain Containing 1
snRNA	Small Nuclear RNA
snoRNA	Small Nucleolar RNA
SOCS1	Suppressor Of Cytokine Signaling 1
SOCS3	Suppressor Of Cytokine Signaling 3
SOMA	Somatotropin
Sox11-b	SRY-Box Transcription Factor 11-B
SP1	Sp1 Transcription Factor
SRA	Sequence Read Archive
SSN-1	Striped Snakehead Fish Cells
ssRNA	Single Stranded RNA
STAR	Steroidogenic Acute Regulatory Protein
STAT	Signal Transducer And Activator Of Transcription
STAT1	Signal Transducer And Activator Of Transcription 1
STAT2	Signal Transducer And Activator Of Transcription 2
STAT3	Signal Transducer And Activator Of Transcription 3

STAT5b	Signal Transducer And Activator Of Transcription 5B
STX17	Syntaxin-17
TBK1	TANK-Binding Kinase 1
STING	Stimulator Of Interferon Genes Protein
TBKBP1	TBK Binding Protein
TCR	T-Cell Receptor
TCR-γ	T-Cell Receptor Gamma
TGF-b	Transforming Growth Factor Beta
TH1-5	Tilapia Hepcidin 1-5
TLR	Toll-Like Receptor
TLR3	Toll-Like Receptor 3
TLR7	Toll-Like Receptor 7
TLR8	Toll-Like Receptor 8
TLR9	Toll-Like Receptor 9
TLR21	Toll-Like Receptor 21
TM	Tropomyosin
TNF-a	Tumor Necrosis Factor Alpha
TNFAIP3	Tnf Alpha Induced Protein 3
TnT	Fast/White Muscle Troponin T
TNV	Turbot Nervous Necrosis Virus
TPNNV	Tiger Puffer Nervous Necrosis Virus
TRAF2	Tnf Receptor Associated Factor 2
TRAF3	Tnf Receptor Associated Factor 3
TRAF6	Tnf Receptor Associated Factor 6
TRAIL	TNF-Related Apoptosis-Inducing Ligand
TRAP1	Tnf Receptor Associated Protein 1
Treg	Regulatory T Cell

TREX	Three Prime Repair Exonuclease
TRIM21	Tripartite Motif Containing 21
TRIM39	Tripartite Motif Containing 39
TSH	Thyrotropin
UNC45b	Unc-45 Myosin Chaperone B
u-PAR	Urokinase Plasminogen Activator Surface Receptor
UPR	Unfolded Protein Response
VAMP8	Vesicle-Associated Membrane Protein 8
VER	Vacuolating Encephalopathy And Retinopathy
viperin	Radical S-Adenosyl Methionin Domain-Containing Protein 2
VLIG	Very Large Inducible GTPASE
VNN	Viral Nervous Necrosis
VRC	Viral Replication Complex
VRG	Virus Responsive Gene
VSG	Variant Surface Glycoprotein
WDR55	Wd Repeat Domain 55
wt	Wild Type
XBP-1	X-Box Binding Protein 1
ZNFX1	Zinc Finger Nfx1-Type Containing 1
3BHSD	Beta-Hydroxysteroid Dehydrogenase
5HT3E	Serotonin Receptor 5-Hydroxytryptamine Receptor 3E
25HC	25-Hydroxycholesterol