

## Supplementary Material

### Ecology and Evolution of facilitation among parasites: causes and consequences

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**Supplementary Table 1. Examples of selected studies that have shown facilitation between parasites.** 1<sup>st</sup> column: host species full name, strains, genotypes, varieties, or breed (when applicable). 2<sup>nd</sup> and 3<sup>rd</sup> columns: "Facilitator" and "Facilitated" parasites species full names, strains, genotypes, or varieties (when applicable), and mode of transmission (H: horizontally; V: vertically; M: mixed transmission mode). 4<sup>th</sup> column: symmetry of the interaction ("+": positive; "-": negative; "0": neutral; "?": unknown effect for each partner of the interaction; 1st: facilitator; second: facilitated). 5<sup>th</sup> column: order of infection (F<sup>R</sup>: facilitator; F<sup>D</sup>: facilitated), and time interval between infections for sequential infections; "simultaneous": both parasites were inoculated at the same time. 6<sup>th</sup> to 8<sup>th</sup> columns: effect of facilitation on infection "success" (i.e. establishment, occurrence or prevalence), infection "intensity" (i.e. parasite load, growth, and/or development), and transmission of facilitated parasites. 9<sup>th</sup> column: consequences for the host fitness (i.e. virulence). 10<sup>th</sup> column: underlying mechanism when known; 11<sup>th</sup> column: type of study (L: laboratory; F: field; R: review; M: meta-analysis); 12<sup>th</sup> column: reference(s). Other abbreviations: ↑: increase; ↓: decrease; ↔: not affected; "?": unknown; "-": not studied; "na": not applicable.

Host	Facilitator	Facilitated	Sym.	Infection order	success	intensity	transm.	host fitness	Mechanism	Type	Ref.
Rabbit ( <i>Oryctolagus cuniculus</i> )	strongylid nematode ( <i>Graphidium strigosum</i> )	H strongylid nematode ( <i>Trichostrongylus retortaeformis</i> )	H	-/+	na	-	↑	-	-	?	F [1]
Nematode ( <i>Caenorhabditis elegans</i> ; strain N2 wild-type)	<i>Staphylococcus aureus</i> (bacteria; strain MSSA 476)	H <i>Enterococcus faecalis</i> (bacteria; strain OG1RF)	H	-/+	simultaneous	-	↑	-	↑ mortality	Supplied-product	L [2]
Fruit fly ( <i>Drosophila simulans</i> ; strain Riverside)	<i>Wolbachia</i> (alphaproteobacteria; strain wRi)	V Parasitoid wasp ( <i>Leptopilina heterotoma</i> )	H	-/+	na	↑	-	-	↑ mortality ↓ size ↓ fecundity ↓ defences	Immunosuppression	L [3]
spider mite ( <i>Tetranychus piercei</i> )	<i>Wolbachia</i> (alphaproteobacteria)	V <i>Cardinium</i> (flavobacterium)	V	-/+	na	-	↑	↑ <sup>a</sup>	↑ fitness relative to uninfected hosts	Reproductive manipulation	L [4]
Tomato leaflets ( <i>Solanum lycopersicum</i> , cv Heinz)	Spider mite ( <i>T. urticae</i> , 4 populations)	H Spider mites ( <i>Tetranychus evansi</i> , 2 pop.)	H	-/+	simultaneous	-	↑ <sup>b</sup>	-	na	?	L [5]
Tomato plant ( <i>Solanum lycopersicum</i> cv Castlemart, 35S::prosystemin)	Spider mites ( <i>T. evansi</i> , Algarrobo1 and Viçosa1)	H Spider mite ( <i>T. urticae</i> , Santpoort-2)	H	-/+	simultaneous; no contact	-	↑	-	↓ defence gene expression <sup>c</sup>	Immunosuppression	L [6]
	Spider mites ( <i>T. urticae</i> , DeLier-1)	H Spider mite ( <i>T. urticae</i> , Santpoort-2)	H	-/+	simultaneous; no contact	-	↑	-	↓ defence (late) gene expression <sup>c</sup>	Immunosuppression	

Host	Facilitator	Facilitated	Sym.	Infection order	success	intensity	transm.	host fitness	Mechanism	Type	Ref.		
Tomato plant ( <i>Solanum lycopersicum</i> cv Santa Clara- 5300)	Spider mites ( <i>Tetranychus evansi</i> )	Spider mite ( <i>Tetranychus urticae</i> )	H	H	-/+	F <sup>R</sup> then F <sup>D</sup> (0-4,7 days); no coinfection	-	↑ <sup>d</sup>	-	↓ JA-inducible defences	Immunosuppression	L	[7,8]
Tomato plant ( <i>Solanum lycopersicum</i> )	Tomato russet mite ( <i>Aculops lycopersici</i> )	Spider mites ( <i>Tetranychus urticae</i> )	H	H	-/+	simultaneous	-	↑	-	↑ SA- ↓ JA-inducible defences	Immunosuppression Immune trade-off	L	[9]
Humans ( <i>Homo sapiens</i> )	Human immunodeficiency virus type 1 (HIV-1)	Malaria parasite ( <i>P. falciparum</i> ; protozoan)	M	H	+/+	F <sup>R</sup> then F <sup>D</sup> (na)	↑	↑	-	↓ defences ↑ anemia ↑ postnatal mortality	Immunosuppression	R	[10]
	Malaria parasite ( <i>P. falciparum</i> ; protozoan)	Human immunodeficiency virus type 1 (HIV-1)	M	H	+/+	F <sup>R</sup> then F <sup>D</sup> (na)	-	↑	-		Immune-mediated		
Humans ( <i>Homo sapiens</i> )	Herpes simplex virus (HSV2)	Human immunodeficiency virus type 1 (HIV-1)	H	M	+/+	na	?	↑	?	↑ Mucocutaneous lesions ↑ disease severity	Immune/ressource-mediated Transactivation /mechanical	R	[11]
	Human immunodeficiency virus type 1 (HIV-1)	Herpes simplex virus (HSV2)	H	M	+/+	na	↑	↑	↑	↑ disease severity	immunosuppression		
Ex vivo lymphoid tissue ( <i>Homo sapiens</i> )	Human immunodeficiency virus type 1 (HIV-1)	Human cytomegalovirus (HCMV)	M	M	+/+	F <sup>D</sup> then F <sup>R</sup> (overnight)	-	↑	-	-	Immunosuppression Ressource-mediated	L	[12]
Ex vivo semen ( <i>Homo sapiens</i> )	Human cytomegalovirus (HCMV)	Human immunodeficiency virus type 1 (HIV-1)	M	M	+/+	unknown	-	↑	-	-	?	L	[13]
Mice ( <i>Mus musculus</i> ; strain BALB/c)	<i>Bordatella bronchiseptica</i> (bacteria; strain RB50)	Helminth ( <i>Heligmosomoides polygyrus</i> )	H	H	+/+	simultaneous	↑	↑	↑ <sup>e</sup>	↑ mortality	?	L	[14]
	Helminth ( <i>Heligmosomoides polygyrus</i> )	<i>Bordatella bronchiseptica</i> (bacteria; strain RB50)	H	H	+/+		-	↑	-				
Mice ( <i>Mus musculus</i> ; strain BALB/c)	Canine influenza virus (CIV; strain H3N2)	<i>Staphylococcus pseudintermedius</i> (bacteria)	H	H	+/+	F <sup>R</sup> then F <sup>D</sup> (72h)	-	↑	-	↑ weight loss ↑ brain lesions ↑ lung injury	?	L	[15]
	<i>Staphylococcus pseudintermedius</i> (bacteria)	Canine influenza virus (CIV; strain H3N2)	H	H	+/+	F <sup>D</sup> then F <sup>R</sup> (72h)	-	↑	-				
Rabbit ( <i>Oryctolagus cuniculus</i> )	Anoplocephaloid cestodes ( <i>Mosgovoyia pectinata</i> )	Oxyurid nematode ( <i>Passalurus ambiguus</i> )	H	H	+/+	na	-	↑	-	-	?	F	[1]
	Oxyurid nematode ( <i>Passalurus ambiguus</i> )	Anoplocephaloid cestodes ( <i>Mosgovoyia pectinata</i> )	H	H	+/+	na	-	↑	-	-	?		
Marine worm ( <i>Olavius algarvensis</i> )	Sulphur-oxidizers gammaproteobacterial symbionts (γ1 and γ3)	Sulphate-reducers deltaproteobacterial symbionts (δ1 and δ4)	?	?	+/+	na	-	-	-	Allow survival <sup>f</sup>	Supplied-product	M	[16]
Shrimps ( <i>Artemia franciscana</i> and <i>A. parthenogenetica</i> )	Cestode ( <i>Flamingolepis liguloides</i> )	Microsporidia ( <i>Anostracospira rigaudi</i> and <i>Enterocytozpora artemiae</i> )	H	H	+/+	na	-	-	↑	na	Behavioural manipulation	F	[17]
Diverse arthropod hosts (Lepidoptera, Coleoptera, Hymenoptera and Hemiptera)	Ichneumonoid parasitoid wasps ( <i>Braconidae</i> and <i>Ichneumonidae</i> )	Polydnaviruses ( <i>Polydnaviridae</i> : <i>Bracovirus</i> and <i>Ichnovirus</i> )	H	V	+/+	na	↑	-	↑	-	Nested parasite	R	[18]
	Polydnaviruses ( <i>Polydnaviridae</i> : <i>Bracovirus</i> and <i>Ichnovirus</i> )	Ichneumonoid parasitoid wasps ( <i>Braconidae</i> and <i>Ichneumonidae</i> )	H	V	+/+	na	↑	-	-	↑ mortality	Immune-mediated		
Mosquito ( <i>Anopheles stephensi</i> )	Malaria parasite ( <i>P. chabaudi</i> ; strain AJ; protozoan)	Malaria parasite ( <i>P. chabaudi</i> ; strain ER; protozoan)	H	H	+/+	F <sup>R</sup> then F <sup>D</sup> (4 days)	↑	↑	-	↔ survival	?	L	[19]
	Malaria parasite ( <i>P. chabaudi</i> ; strain ER; protozoan)	Malaria parasite ( <i>P. chabaudi</i> ; strain AJ; protozoan)	H	H	+/+	F <sup>R</sup> then F <sup>D</sup> (4 days)	↑	↑	-	↔ survival	?		
Spider mite ( <i>Tetranychus phaselus</i> )	<i>Wolbachia</i> (alphaproteobacteria; wCon) and <i>Cardinium</i> (flavobacterium)	<i>Wolbachia</i> (alphaproteobacteria; wOri)	V	V	+/+	na	-	-	↑ <sup>a</sup>	↓ fecundity <sup>g</sup> ↔ longevity	Reproductive manipulation	L	[20]
	<i>Wolbachia</i> (alphaproteobacteria; wOri)	<i>Wolbachia</i> (alphaproteobacteria; wCon) and <i>Cardinium</i> (flavobacterium)	V	V	+/+	na	-	↑ <sup>h</sup>	↔	↓ fecundity <sup>g</sup> ↑ longevity	?		

Host	Facilitator	Facilitated	Sym.	Infection order	success	intensity	transm.	host fitness	Mechanism	Type	Ref.
Spider mite ( <i>Tetranychus truncates</i> )	<i>Cardinium</i> (flavobacterium)	V <i>Wolbachia</i> (alphaproteobacteria)	V +/+	na	-	↑	↑ <sup>a</sup>	↑ fecundity ↔ longevity	Reproductive manipulation	L	[21]
	<i>Wolbachia</i> (alphaproteobacteria)	V <i>Cardinium</i> (flavobacterium)	V +/+	na	-	↑	↑ <sup>a</sup>	↑ fecundity ↔ longevity	Reproductive manipulation		
Tomato plant ( <i>Solanum lycopersicum</i> cv MoneyMaker)	Spider mite ( <i>Tetranychus evansi</i> )	H Spider mite ( <i>Tetranychus evansi</i> or <i>T. ludeni</i> )	H +/+	F <sup>R</sup> then F <sup>D</sup> (2 days); no coinfection	-	↑	-	↓ JA-inducible defences	Immunosuppression	L	[22]
	Spider mite ( <i>Tetranychus ludeni</i> )	H Spider mite ( <i>Tetranychus evansi</i> or <i>T. ludeni</i> )	H +/+	F <sup>R</sup> then F <sup>D</sup> (2 days); no coinfection	-	↑	-	↓ JA-inducible defences	immunosuppression		
Plantain plant ( <i>Plantago lanceolata</i> ; several genotypes)	Powdery mildew fungus ( <i>Podosphaera plantaginis</i> ; strain 10)	H Powdery mildew fungus ( <i>Podosphaera plantaginis</i> ; strain 3)	H +/+	Simultaneous	↑	↑	↑	↑ disease severity	?	LF	[23,24]
	Powdery mildew fungus ( <i>Podosphaera plantaginis</i> ; strain 3)	H Powdery mildew fungus ( <i>Podosphaera plantaginis</i> ; strain 10)	H +/+	Simultaneous	↑	↑	↑	↑ disease severity	?		
Pine moth ( <i>Panolis flammea</i> )	Nucleopolyhedrovirus (PfNPV; Pf4)	H Nucleopolyhedrovirus (PfNPV; Pf6)	H 0/+	simultaneous	-	↑ <sup>h</sup>	-	↑ mortality ↔ time to kill	?	L	[25]
Rabbit ( <i>Oryctolagus cuniculus</i> )	anoplocephaloid cestode ( <i>Cittotaenia denticulata</i> )	H strongylid nematode ( <i>Trichostrongylus retortaeformis</i> )	H 0/+	na	-	↑	-	-	?	F	[26]
Pig ( <i>Sus scrofa domestica</i> ; "Large White" breed)	Scabies mite ( <i>Sarcoptes scabiei</i> , var. suis)	H Bacteria ( <i>Staphylococcus aureus</i> and <i>Streptococcus pyogenes</i> )	H ?/+	F <sup>R</sup> then F <sup>D</sup> (<21 weeks)	↑	↑	-	↓ skin microbiota	?	L	[27]
Mice ( <i>Mus musculus</i> ; strain BALB/c)	Live Attenuated Influenza Vaccine (LAIV; attenuated variant of HK/Syd, HK/Sydat(t)s)	H <i>Streptococcus pneumoniae</i> (bacteria; isolate ST425, serotype 19F)	H ?/+	both ways (7 days) or F <sup>R</sup> then F <sup>D</sup> (4 weeks)	-	↑	-	↑ infection duration ↔ mortality	?	L	[28]
Mice ( <i>Mus musculus</i> ; strain BALB/c)	Live Attenuated Influenza Vaccine (LAIV; attenuated variant of HK/Syd, HK/Sydat(t)s)	H <i>Staphylococcus aureus</i> (strains Wright and Newman)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (1 and 7 days)	-	↑	-	↑ infection duration ↔ mortality	?		
Mice ( <i>Mus musculus</i> ; strain BALB/cbj)	Virus Influenza A (strain H1N1; PR8)	H <i>Streptococcus pneumoniae</i> (bacteria; strain BHN54)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (3 days)	↑	-	-	↑ otitis media ↑ pneumonia	?	L	[29]
Mice ( <i>Mus musculus</i> ; strain C57Bl/6)	Virus Influenza A (strain H3N2; HKx31)	H <i>Pneumococci</i> (serotypes 23F and 4; strains P1121 and TIGR4, respectively)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (24h)	↑	↑	-	↑ mucus ↑ sialic acid (sugar)	Resource-mediated	L	[30]
Mice ( <i>Mus musculus</i> ; strain MF1)	Malaria parasite ( <i>Plasmodium chabaudi</i> ; protozoan)	H Malaria parasite ( <i>Plasmodium yoelii</i> ; protozoan)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (10 days)	-	↑	-	↑ mortality ↑ anemia (↓ RBC ↑ reticulocyte)	Immune-mediated Resource-mediated	L	[31]
Mice ( <i>Mus musculus</i> ; strains BALB/cByJ and C57Bl/6)	Helminth worm ( <i>Taenia crassiceps</i> )	H <i>Streptococcus pneumoniae</i> (type 2 strain D39, type 3 strain A66.1, and type 19F strain BHN97)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (8-10 weeks)	-	↑ <sup>i</sup>	-	↑ weight loss ↑ mortality	?	L	[32]
Ferret ( <i>Mustela putorius furo</i> )	Virus Influenza (strain H3N2)	H <i>Streptococcus pneumoniae</i> (bacteria; strain BHN97)	H ?/+	F <sup>R</sup> then F <sup>D</sup> (3 days)	↑	-	↑	↑ disease severity	?	L	[29]
Rainbow trout ( <i>Oncorhynchus mykiss</i> )	<i>Flavobacterium columnare</i> (6 different bacterial strains)	H Trematode fluke ( <i>Diplostomum pseudospathaceum</i> ; 5 genotypes)	H ?/+	simultaneous	-	↑	-	↑ mortality	?	L	[33]
Rainbow trout ( <i>Oncorhynchus mykiss</i> )	Trematode eye-fluke ( <i>Diplostomum pseudospathaceum</i> ; multiple genotypes)	H Trematode eye-fluke ( <i>Diplostomum pseudospathaceum</i> ; multiple genotypes)	H ?/+	simultaneous	↑	-	-	-	?	L	[34]
Stickleback ( <i>Gasterosteus aculeatus</i> )	Tapeworm ( <i>Schistocephalus solidus</i> ; High and Low growth populations)	H Tapeworm ( <i>Proteocephalus filicolis</i> )	H ?/+	F <sup>R</sup> then F <sup>D</sup> (?)	-	↑	-	-	?	F	[35]

Host	Facilitator	Facilitated	Sym.	Infection order	success	intensity	transm.	host fitness	Mechanism	Type	Ref.	
Stickleback ( <i>Gasterosteus aculeatus</i> )	Tapeworm ( <i>Schistocephalus solidus</i> ; High growth populations)	Trematode eye-fluke ( <i>Diplostomum pseudospathaceum</i> )	H	?/+	F <sup>R</sup> then F <sup>D</sup> (41-43 days)	-	↑	-	-	?	F	[35]
Citrus mealybugs ( <i>Planococcus citri</i> )	β-Proteobacteria	γ-Proteobacteria	V	?/+	na	↑	-	↑	-	Nested parasite	L	[36]
African armyworm ( <i>Spodoptera exempta</i> )	<i>Wolbachia</i> (alphaproteobacteria; wExe1 and 2)	Nucleopolyhedrovirus (Armyworm SpexNPV)	V	?/+	na	↑	↑	-	↑ mortality	?	LF	[37]
Honeybees ( <i>Apis mellifera</i> )	Parasitic mite ( <i>Varroa destructor</i> )	Deformed wing virus (DWV)	H	?/+	F <sup>D</sup> then F <sup>R</sup> (unknown)	↑	↑	-	↑ mortality; (colony collapse)	Immunosuppression	F	[38]
Mosquito ( <i>Anopheles gambiae</i> )	<i>Wolbachia</i> (alphaproteobacteria; wAlbB)	Malaria parasite ( <i>P. berghei</i> ; ANKA 2.34; protozoan)	V	?/+	na	↔	↑	-	↔ survival	?	L	[39]
Mosquito ( <i>Culex pipiens</i> ; strain Slab)	<i>Wolbachia</i> (alphaproteobacteria; wPip(SI))	Malaria parasite ( <i>P. relictum</i> ; strain SGS1; protozoan)	V	?/+	na	↑	↑	-	↑ longevity ↓ induced mortality	?	L	[40,41]
Diverse herbivorous insect vectors and host plants	Potyvirus, waikaviruses, caulimoviruses	Potato aucuba virus (potyvirus) Rice tungro bacilliform virus (waikavirus)	H	?/+	na	↑	-	↑	na	Transcomplementation	R	[42-44]
Diverse plant families and aphid vectors	<i>Luteoviruses</i>	<i>Umbraviruses</i>	H	?/+	na	↑	-	↑	na	Transcapsidation	R	[45,44]
Mousear Cress plant ( <i>Arabidopsis thaliana</i> ; mutant nahG and npr1 and WT col-0)	<i>Pseudomonas syringae</i> (bacterial phytopathogen; Psm ES4326 and cfa6::Kmr)	Cabbage looper ( <i>Trichoplusia ni</i> ; inbred pop.)	H	?/+	F <sup>R</sup> then F <sup>D</sup> (4 days)	-	↑	-	-	? <sup>k</sup>	L	[46,47]
Mousear Cress plant ( <i>Arabidopsis thaliana</i> ; mutant npr1 and WT col-0)	<i>Pseudomonas syringae</i> (bacterial phytopathogen; strains Psm ES4326 and Pst DC3000)	<i>Pseudomonas syringae</i> (bacterial phytopathogen; strain Psm ES4326)	H	?/+	F <sup>R</sup> then F <sup>D</sup> (4 days)	-	↑	-	↓ SA-inducible defences	Immunosuppression	L	[47]
Mousear Cress plant ( <i>Arabidopsis thaliana</i> ; col-0)	Tomato Spotted Wilt Virus (Topsovirus ; isolate 0)	Western flower thrips ( <i>Frankliniella occidentalis</i> )	H	?/+	Simultaneous	-	↑	-	↑ feeding scars ↑ SA-inducible defences	Behavioural manipulation Immune trade-off	L	[48]
Pepper plant ( <i>Capsicum annuum</i> )	Tomato Spotted Wilt Virus (Topsovirus )	Western flower thrips ( <i>Frankliniella occidentalis</i> )	H	?/+	F <sup>R</sup> then F <sup>D</sup> (2 weeks)	-	↑	-	-	?	L	[49]
Tomato plant ( <i>Solanum lycopersicum</i> cv Moneymaker)	Tomato Spotted Wilt Virus (Topsovirus ; isolate TSWV-MT2)	Spider mite ( <i>Tetranychus urticae</i> )	H	?/+	F <sup>R</sup> then F <sup>D</sup> (5 weeks)	-	↑	-	↑ defences ↑ amino acid	?	L	[50]

<sup>a</sup> due to cytoplasmic incompatibility.

<sup>b</sup> population dependent effect

<sup>c</sup> downstream of JA and SA accumulation

<sup>d</sup> only in absence of coinfection: *T. urticae* is outcompeted by *T. evansi* when sharing the same leaf

<sup>e</sup> but no difference in the per capita (per helminth) number of eggs

<sup>f</sup> compensate for the loss of digestive and excretory systems (γ-bacteria produce CO<sub>2</sub> by the oxidation of reduced inorganic compounds e.g. sulphide to sulphate. δ-bacteria reduce sulphate products produced by the γ-bacteria, producing sulphide)

<sup>g</sup> male effect on fecundity

<sup>h</sup> age-dependent effect on intensity

<sup>i</sup> intensity increase in the lungs only

<sup>j</sup> only when the host is feeding on its native host *Pinus sylvestris* but not *P. contorta*

<sup>k</sup> systemic response of the host

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