
بسم الله الرحمن الرحيم

ظرفیت ناقلی و خصوصیات رفتاری بندپایان: اهمیت در انتقال بیماری های زئونوز انگلی

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دانشیار گروه بیولوژی و کنترل ناقلین بیماری ها

Table 1. Global burden of VBDs.

	Data source	Estimated cases worldwide in 2017 (thousands [95% CI])	Estimated global all-age DALYs in 2017 (thousands [95% CI])	Estimated all-age deaths worldwide in 2017 (thousands [95% CI])
Malaria	World Malaria Report 2018 [8]	219,000 (203,000–262,000)	Not stated	435
	Global Burden of Disease 2017 [6, 7, 9]	208,768 (170,214–257,506)	45,000 (31,700–61,000)	619.8 (440.1–839.5)
Dengue	Global Burden of Disease 2017 [6, 7, 9]	104,771 (63 759–158,870)	2,920 (1,630–3,970)	40.5 (17.6–49.8)
CL and mucocutaneous leishmaniasis		4,166.6 (3,560.7–4,992.8)*	264 (172–389)	-
VL		10.6 (8.2–16.5)*	511 (1.02–2,440)	7.5 (0.0–34.5)
Yellow fever		97.4 (28.0–251.7)	314 (67.2–900)	4.8 (1.0–13.8)
Chagas disease		6,197.0 (5,248.5–7,243.9)*	232 (210–261)	7.9 (7.5–8.6)
HAT		4.9 (1.3–19.8)*	79.0 (15.4–287)	1.4 (0.3–4.9)
LF		64,623.4 (59,178.2–70,866.1)*	1,360 (752–2,160)	-
Onchocerciasis		20,938.1 (12,882.3–37,227.7)*	1,340 (639–2,370)	-
Trachoma		3,818.9 (2,842.6–5,135.2)*	303 (202–425)	-
Zika virus disease		2,232.2 (1,659.6–3,097.6)	2.24 (1.27–4.66)	0.0 (0.0–0.1)

*Prevalence.

Abbreviations: CL, cutaneous leishmaniasis; DALY, disability-adjusted life year; HAT, human African trypanosomiasis; LF, lymphatic filariasis; VBD, vector-borne disease; VL, visceral leishmaniasis

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Wilson AL, Courtenay O, Kelly-Hope LA, Scott TW, Takken W, et al. (2020) The importance of vector control for the control and elimination of vector-borne diseases. PLOS Neglected Tropical Diseases 14(1): e0007831. https://doi.org/10.1371/journal.pntd.0007831
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Complexity of VBDs

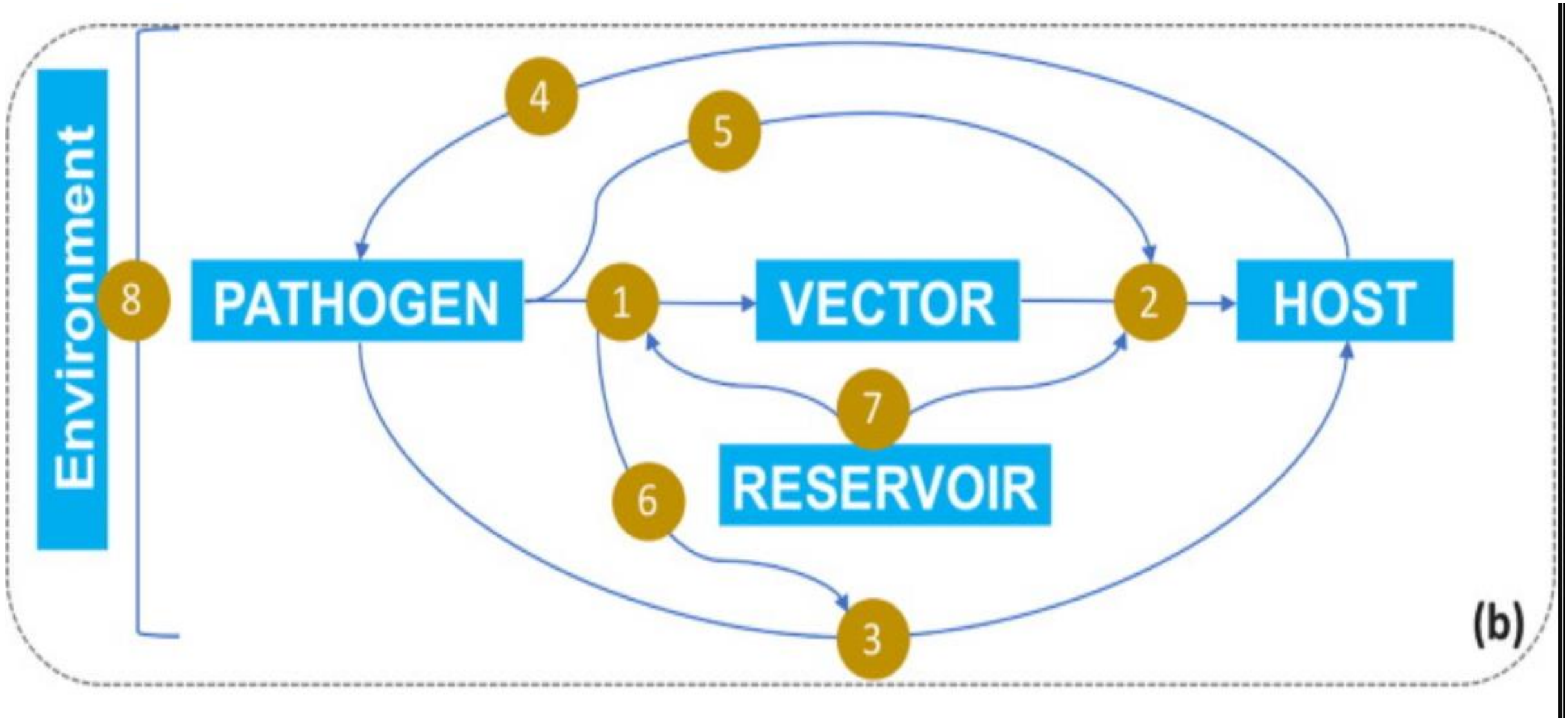
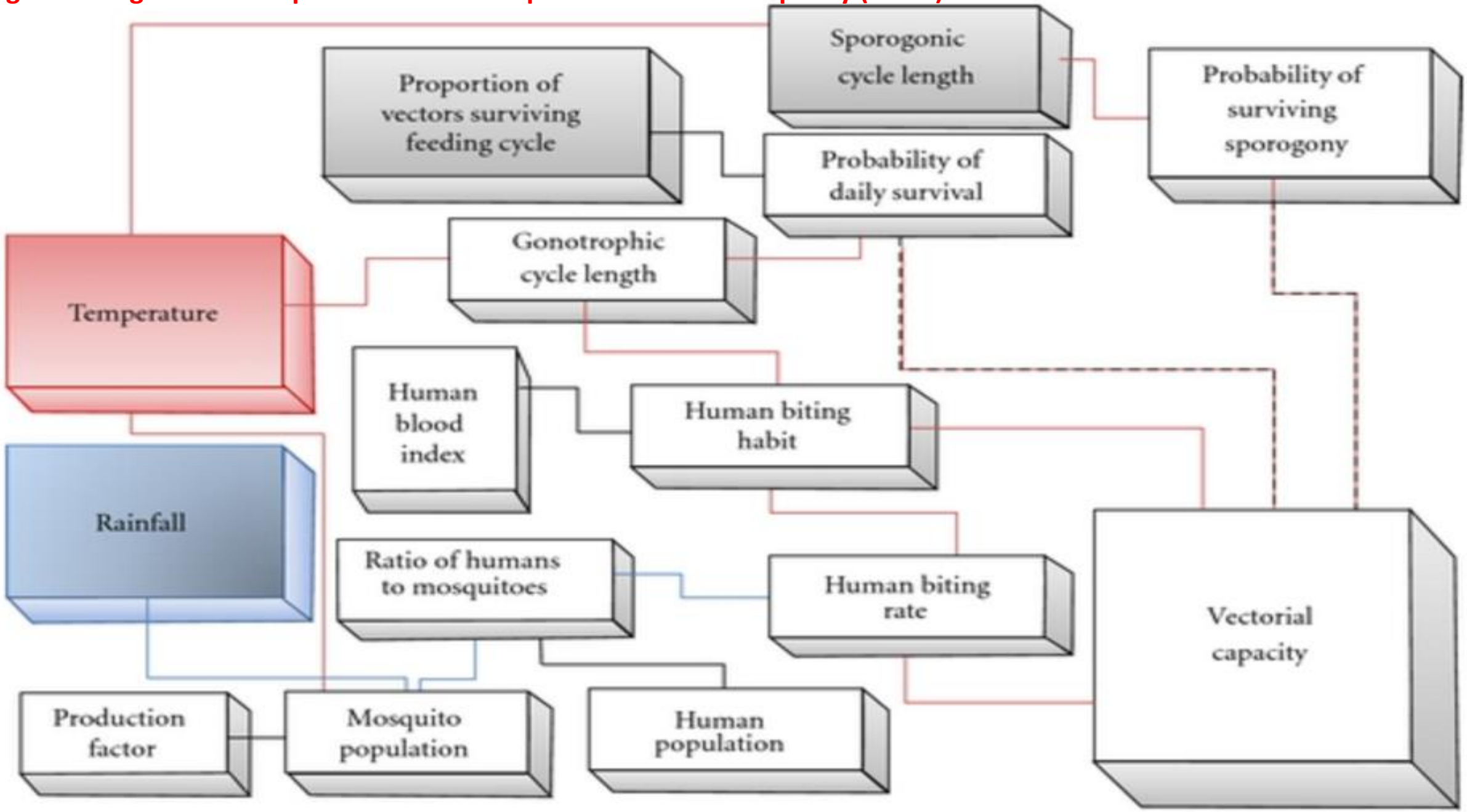


Figure 1 Diagrammatic representation of "expanded" vectorial capacity (VCAP) Model.



Ecological differences between vectors vs non-vectors

- **Larval habitats**
- **Mating behavior**
- **Biting behavior**
- **House-entering behavior**
- **Feeding behavior**
- **Resting behavior**

Fig 2. Age-structured vectorial capacity

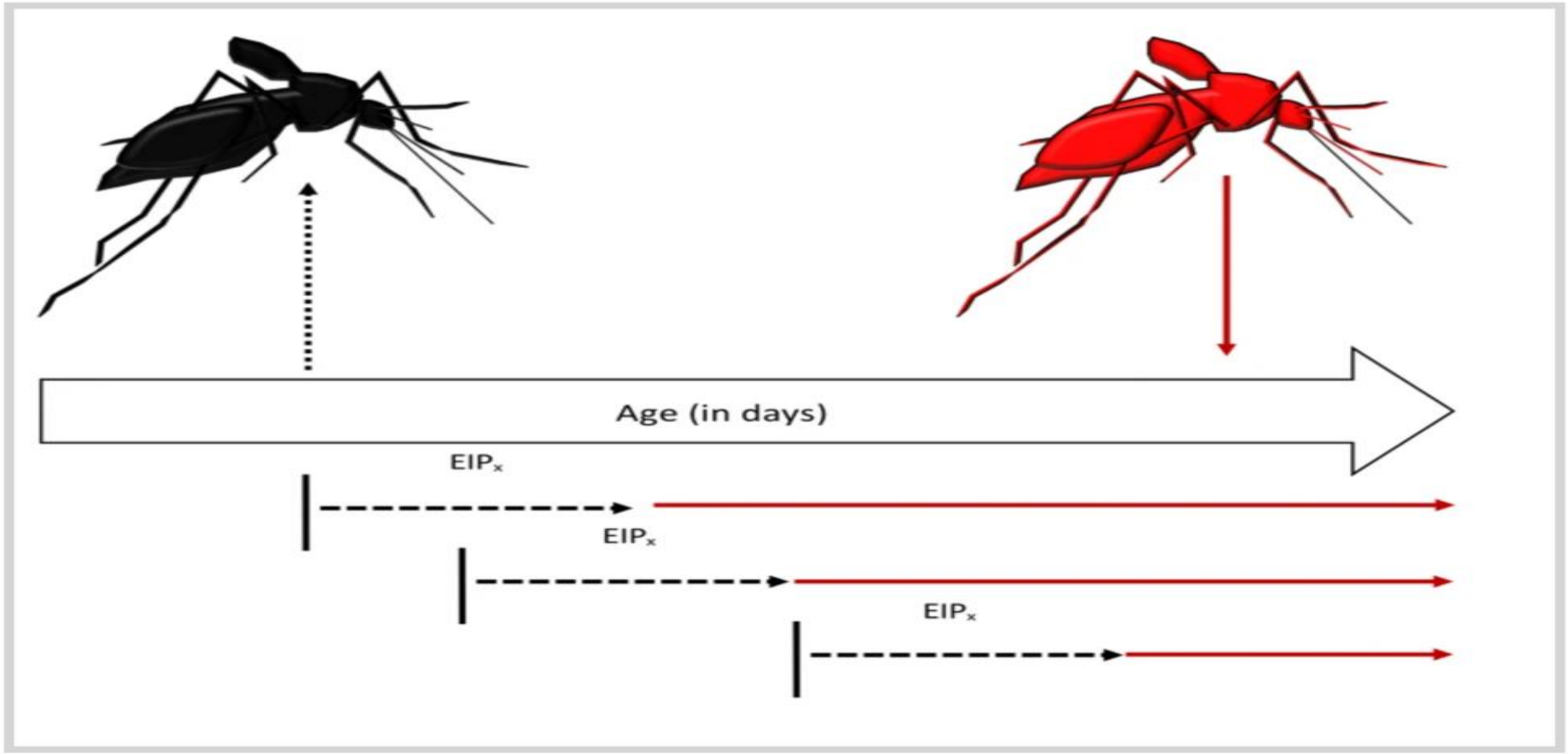
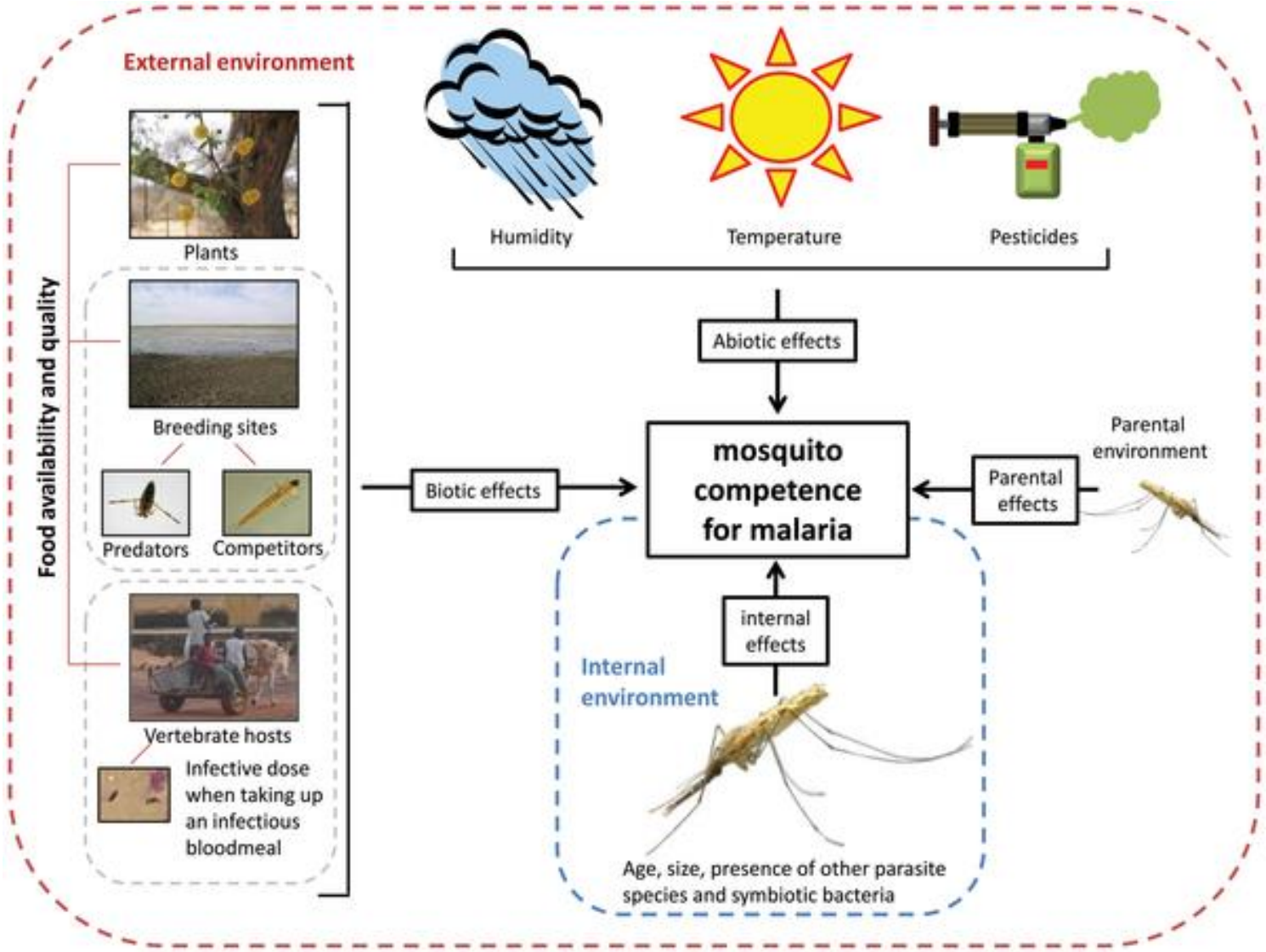


Figure 3. Diversity of ways in which non-genetic factors may influence mosquito competence for malaria parasites.



Lefèvre T, Vantaux A, Dabiré KR, Mouline K, Cohuet A (2013) Non-Genetic Determinants of Mosquito Competence for Malaria Parasites. PLOS Pathogens 9(6): e1003365.
https://doi.org/10.1371/journal.ppat.1003365 https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1003365

Table 2. Existing evidence for non-genetic influences on mosquito competence for malaria parasites.

Factor	Effect and magnitude	Biological system	Refs
Temperature	Parasite development rate increased with temperature until a threshold was reached, at which point parasite survival sharply decreased.	*An. stephensi* - *P. falciparum* *An. stephensi* - *P. falciparum*	[32] [33]
	Within the parasite thermal limit, high temperatures accelerated parasite development but decreased vector competence. A change from 22°C to 26°C resulted in a five-fold decrease in sporozoite prevalence of *P. yoelii*-infected *An. stephensi*.	*An. stephensi* - *P. yoelii* *An. quadrimaculatus* & *An. stephensi* - *P. berghei*	[34] [36]
	Within the parasite thermal limit, high temperatures decreased vector competence. Temperature increases from 27°C to 30°C and 32°C reduced oocyst prevalence from 15.9% to 8.5% and 6.4%.	*An. gambiae* - *P. falciparum*	[35]
	Compared to an equivalent constant mean temperature, competence increased when diurnal fluctuations occurred around low mean temperatures (from about 0% to 10% sporozoites prevalence at 16°C) but decreased with fluctuations around high mean temperatures (from 30% to about 0% sporozoites prevalence at 26°C).	*An. stephensi* - *P. chabaudi*	[37]
	Mosquito ability to melanize foreign entities declined with increasing temperatures. The percentage of melanized beads dropped from 63% to 53% and 30% with temperature increases from 24°C to 27°C and 30°C.	*An. gambiae* - Sephadex beads	[28]
	Mosquito immune responses showed complex interactions with temperature, time, and nature of immune challenge.	*An. stephensi* - Sephadex beads, fluorospheres, bacteria	[26]
Food	Glucose-deprived females displayed greater competence than females fed on glucose *ad libitum* (i.e., they harbored about twice as many oocysts).	*An. stephensi* - *P. chabaudi*	[43]
	Females fed on 4% glucose displayed greater competence than females fed on 2% and 6% glucose (i.e., they harbored about twice as many oocysts).	*An. stephensi* - *P. yoelii yoelii*	[42]
	The melanization response to foreign entities showed a two-fold increase with increasing sugar concentration following a blood meal.	*An. stephensi* - Sephadex beads	[46]
	Nutritional deprivation during the larval stages decreased melanization response (i.e., melanization decreased by three-fold with a four-fold decrease in larval food quantity).	*An. gambiae* - Sephadex beads	[28]
	Greater competence in females fed double blood meals compared to single blood meals (i.e., 35% oocyst prevalence on double blood meals compared to 25% on single blood meals).	*An. gambiae* - *P. falciparum*	[44]
Gut microbiota	High bacterial load and diversity decreased competence (i.e., aseptic mosquitoes harbored about 8 times more oocysts than their septic counterparts).	*An. gambiae* - *P. falciparum* & *P. berghei*	[50–52]
	A specific bacterial isolate conferred total refractoriness.	*An. gambiae* - *P. berghei* & *P. falciparum*	[51]
	Field-collected infected mosquitoes harbored about 2.5 times more enterobacteria than uninfected mosquitoes.	*An. gambiae* - *P. falciparum*	[53]
Infection history	Co-infection with entomopathogenic fungi decreased competence (i.e., 35% sporozoite prevalence in malaria-infected mosquitoes compared to 8% in co-infected mosquitoes).	*An. stephensi* - *P. chabaudi* & *Metarhizium anisopliae* & *Beauveria bassiana*	[54]
	Co-infection with microsporidian parasites decreased competence (i.e., 58.5% oocyst prevalence with a mean number of 8.9 oocysts in microsporidian-infected mosquitoes compared to 81.8% and 20.7 in microsporidian-uninfected mosquitoes).	*An. gambiae* - *P. berghei* & *Vavraia culicis* & Sephadex beads	[56]
	Co-infection with filarial worms decreased competence (i.e., about four-fold and 50% decrease in oocyst intensity and prevalence, respectively).	*Armigeres subalbatus* & *Ae. aegypti* - *P. gallinaceum*, *Brugia malayi*, *B. pahangi* & *Dirofilaria immitis*	[55]
	Co-infection with two malaria parasite species decreased competence by two-fold for one of the two malaria species.	*Ae. aegypti* - *P. gallinaceum* & *P. juxtanucleare*	[58]
	Previous malaria infection decreased by three-fold the competence to a subsequent malaria infection.	*An. gambiae* - *P. falciparum* & *P. berghei*	[59]
Maternal effects	Infection with microsporidian parasites decreased competence in the offspring (i.e., 70% of the offspring of microsporidian-free mothers infected with *P. berghei* against 42% of *V. culicis*-infected females). Food deprivation increased the likelihood of infection in the offspring by 32%.	*An. gambiae* - *P. berghei*	[61]
	Offspring from mothers inoculated with foreign entities had a similar melanization response than offspring from unchallenged mothers.	*Ae. aegypti* - Sephadex beads	[60]
Mosquito age	The percentage of melanized beads decreased from 50% in <1-day-old females to about 10% in >1-day-old females.	*An. gambiae* - Sephadex beads	[64]
	No age effect on mosquito susceptibility to entomopathogenic fungi.	*An. gambiae* - *Metarhizium anisopliae* & *Beauveria bassiana*	[65]
	No age effect on competence for malaria parasites.	*An. gambiae* - *P. falciparum*	[44]
Mosquito body size	Melanization response was stronger in large than in small females.	*An. gambiae* - Sephadex beads	[28]
	Competence increased with size.	*An. gambiae* - *P. falciparum* *An. dirus* - *P. falciparum*	[73,74]

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Figure 4. Complex environmental mediation of mosquito competence for malaria parasites.

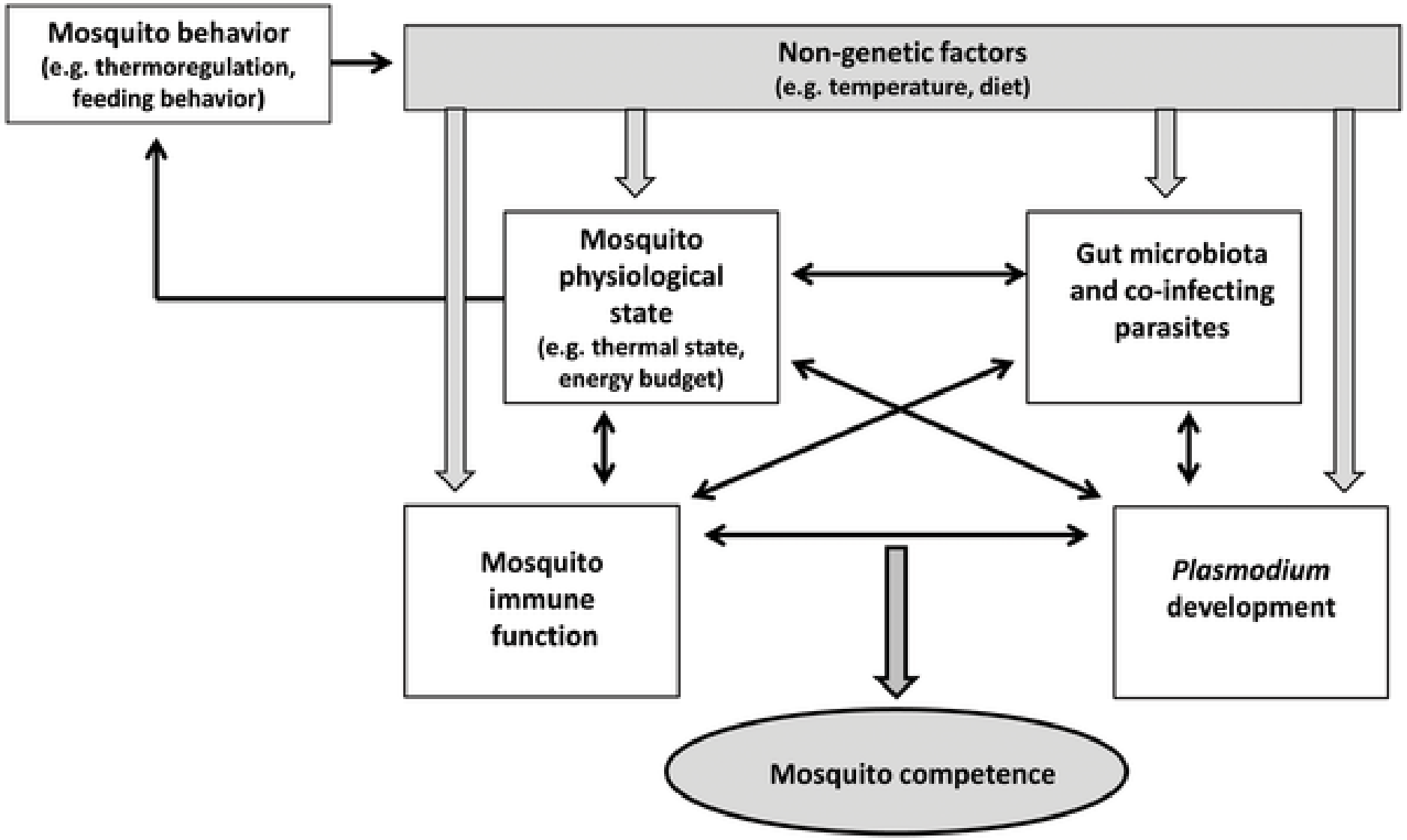

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Figure 5. Disentangling the influence of host genotype, parasite genotype, environment, and interactions.

Mosquito competence for malaria is a complex phenotypic trait determined by host and parasite genetic factors, non-genetic environmental factors and interactions between these factors (A). For example, *An. gambiae*, the primary vector of malaria in Africa, displays a wide range of competence for a given parasite genotype (B.1, [118]); and a given mosquito strain also varies in its susceptibility to different *Plasmodium* isolates (B.2, [88]). Some studies have also demonstrated the existence of vector-parasite genetic interactions (B.3, see also glossary [16,18]). Competence of a given mosquito genotype for a given parasite genotype can vary depending on environmental conditions (B.4). Most of the works reviewed here illustrate this situation (table 1). Environmental influences on competence can also vary depending on host genotype (B.5, G_H x E), parasite genotype (B.6, G_P x E) or both (B.7, G_H x G_P x E). Such interactions have important evolutionary consequences as it creates selection for different vector and/or parasite genotypes under different environmental conditions, hence affecting coevolutionary dynamics of mosquito-parasite interactions and potentially disease dynamics [21,22]. We are aware of only two studies which have investigated G x E interactions in mosquito-malaria associations [42,43]. Both found no G x E effects on competence. However, one cannot rule out the possibility that these results stem from the utilization of unnatural laboratory-based model systems in which host and parasite do not share an evolutionary history. Finally, there can be E x E interactions whereby the effects of a given environmental factor differ depending on other environmental factors (B.8). For example, whereas larval exposure to pesticides increases *Ae. aegypti* competence for arboviruses at high temperature, it has no effect when larvae are reared at low temperature [84].

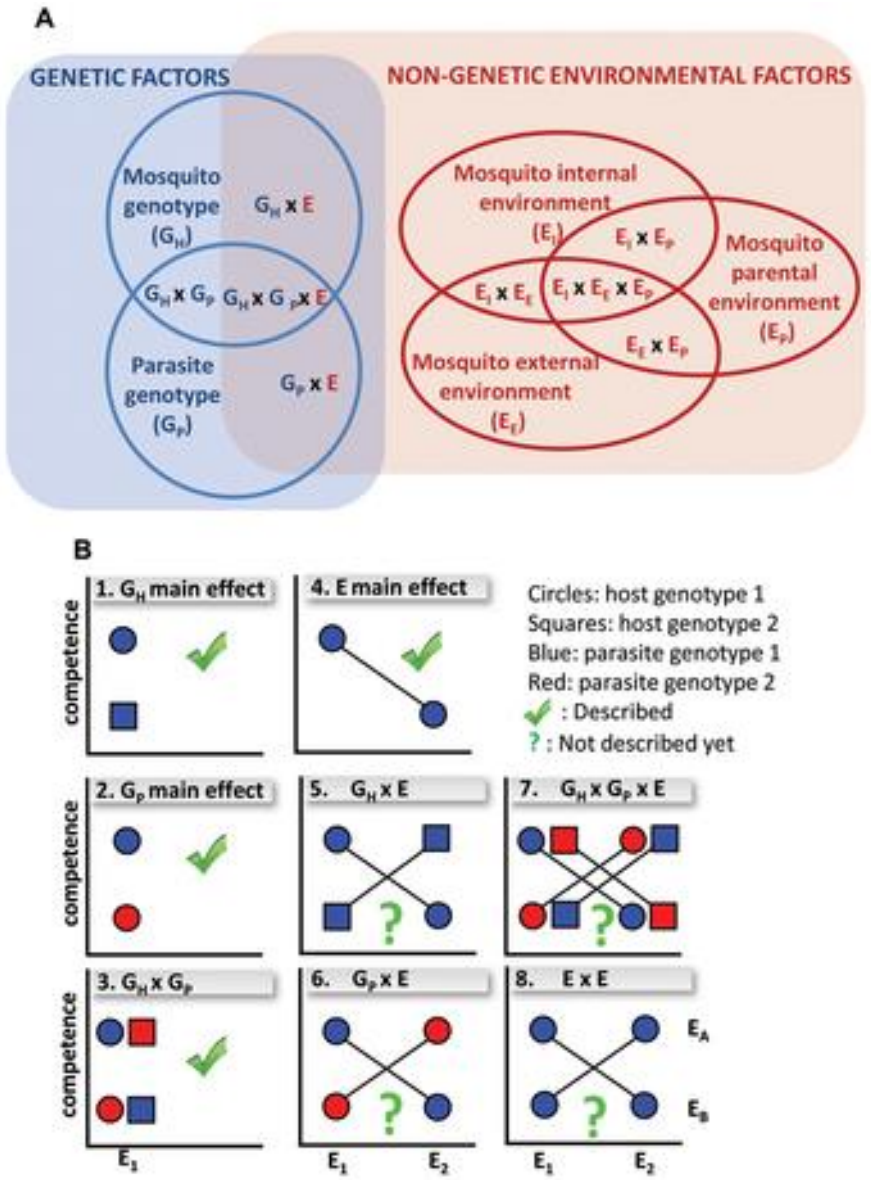

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Fig. 6. Natural and technical confounding factors related to arbovirus vector competence studies in *Aedes aegypti*.

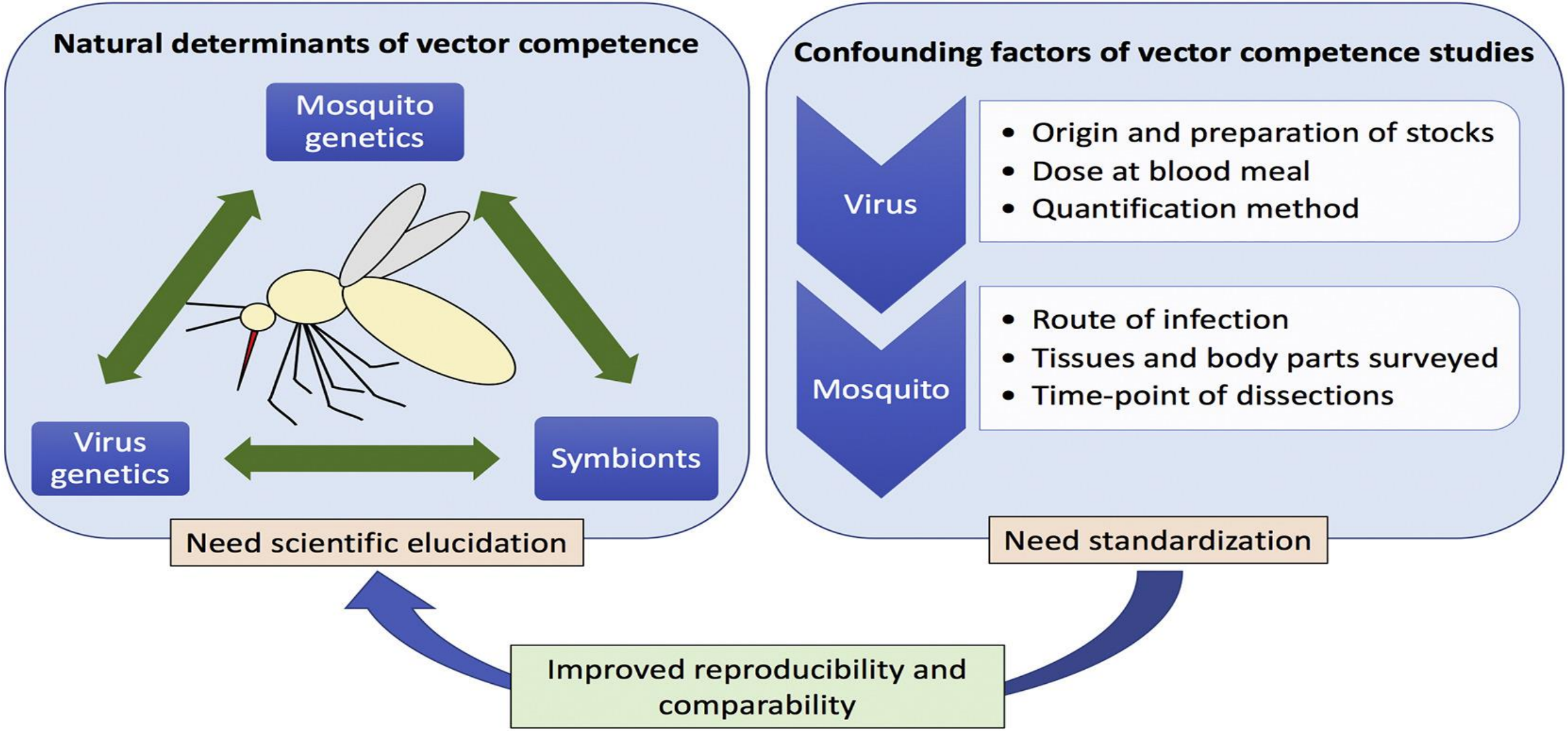


Fig. 7. Interaction of different factors on VBDs

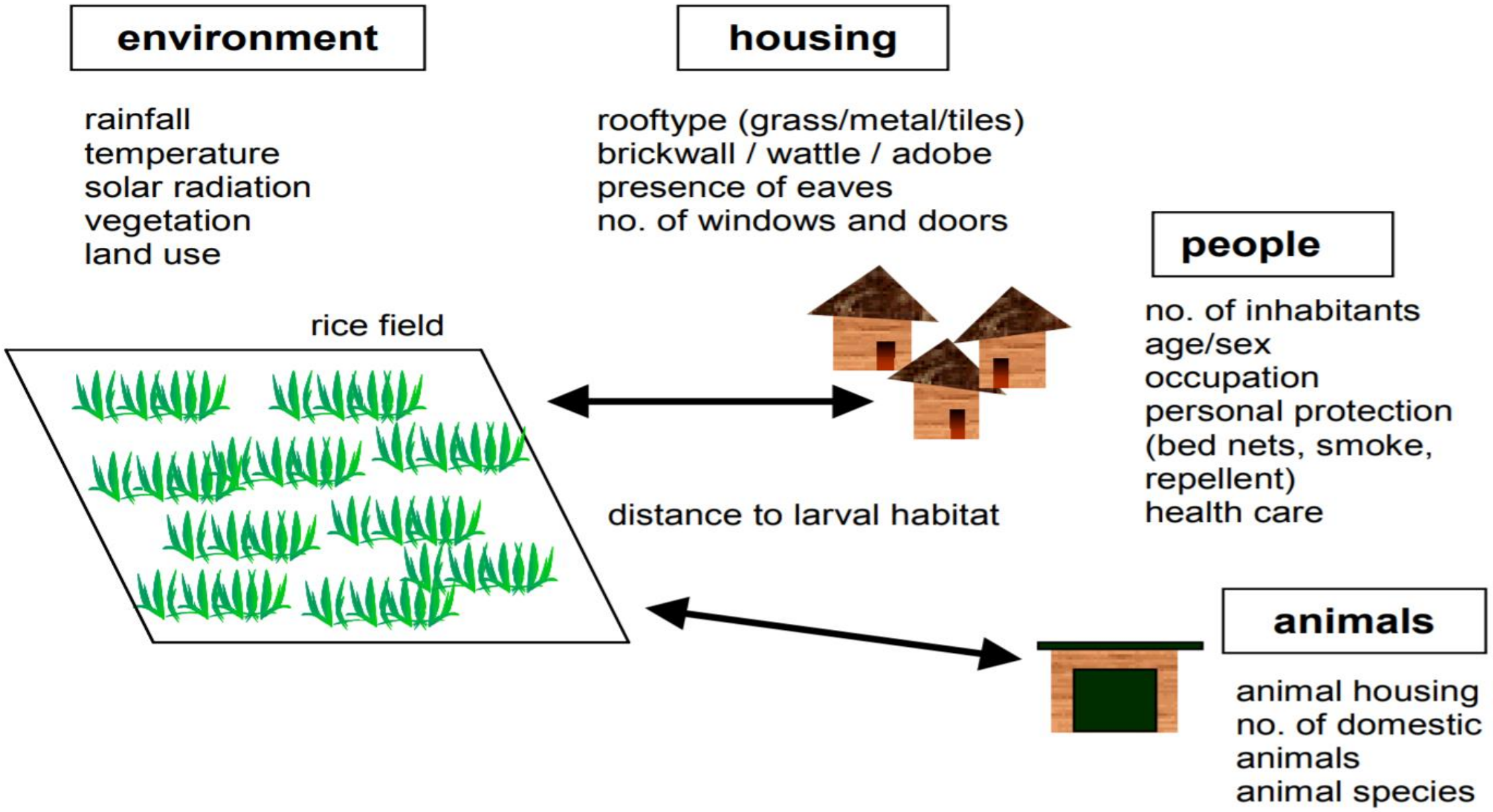
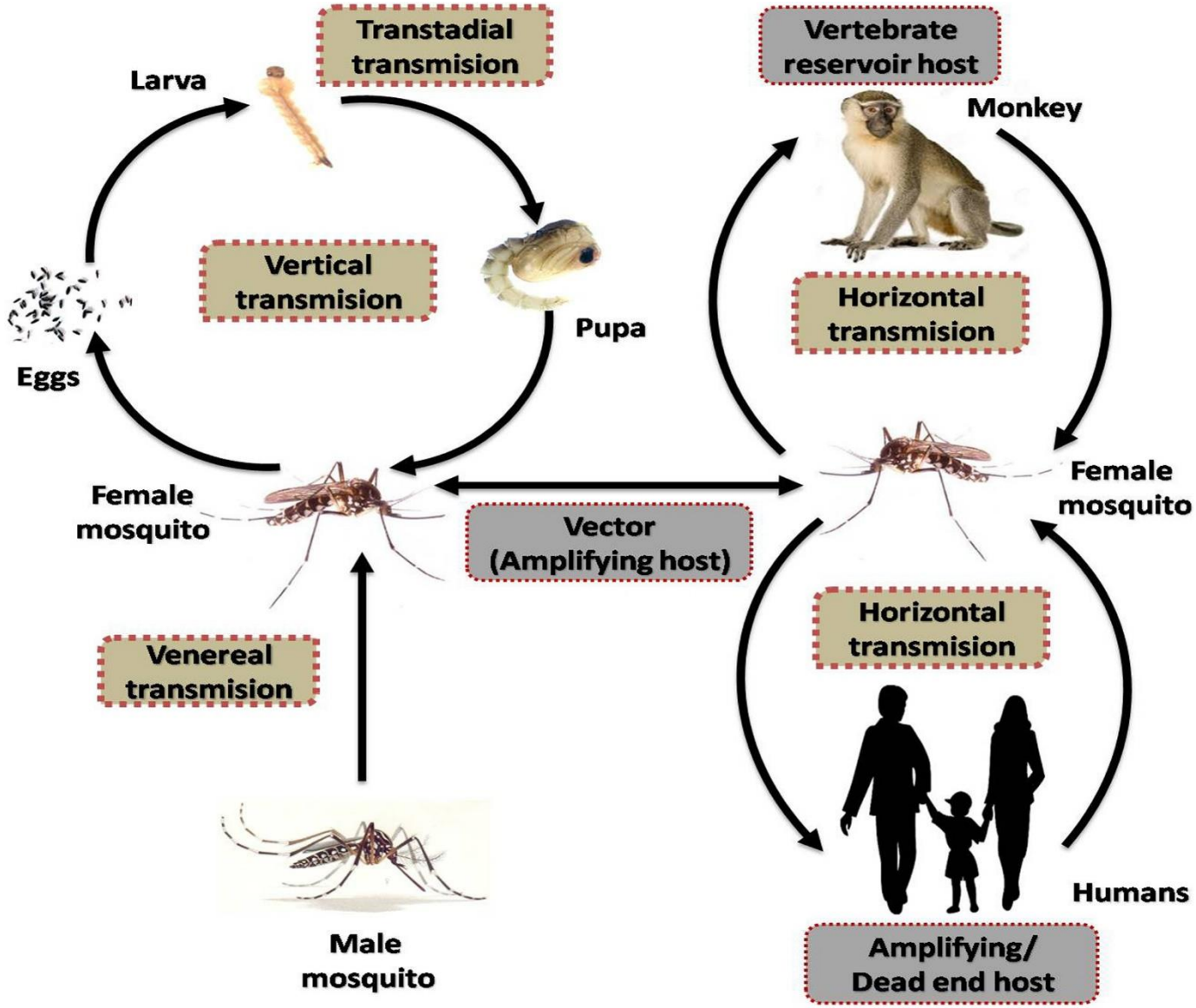


Fig 8. Impact of transmission cycles and vector competence on global expansion and emergence of arboviruses



Reviews in Medical Virology, Volume: 27, Issue: 5, First published: 30 August 2017, DOI: (10.1002/rmv.1941)

Fig 9. Impact of transmission cycles and vector competence on global expansion and emergence of arboviruses

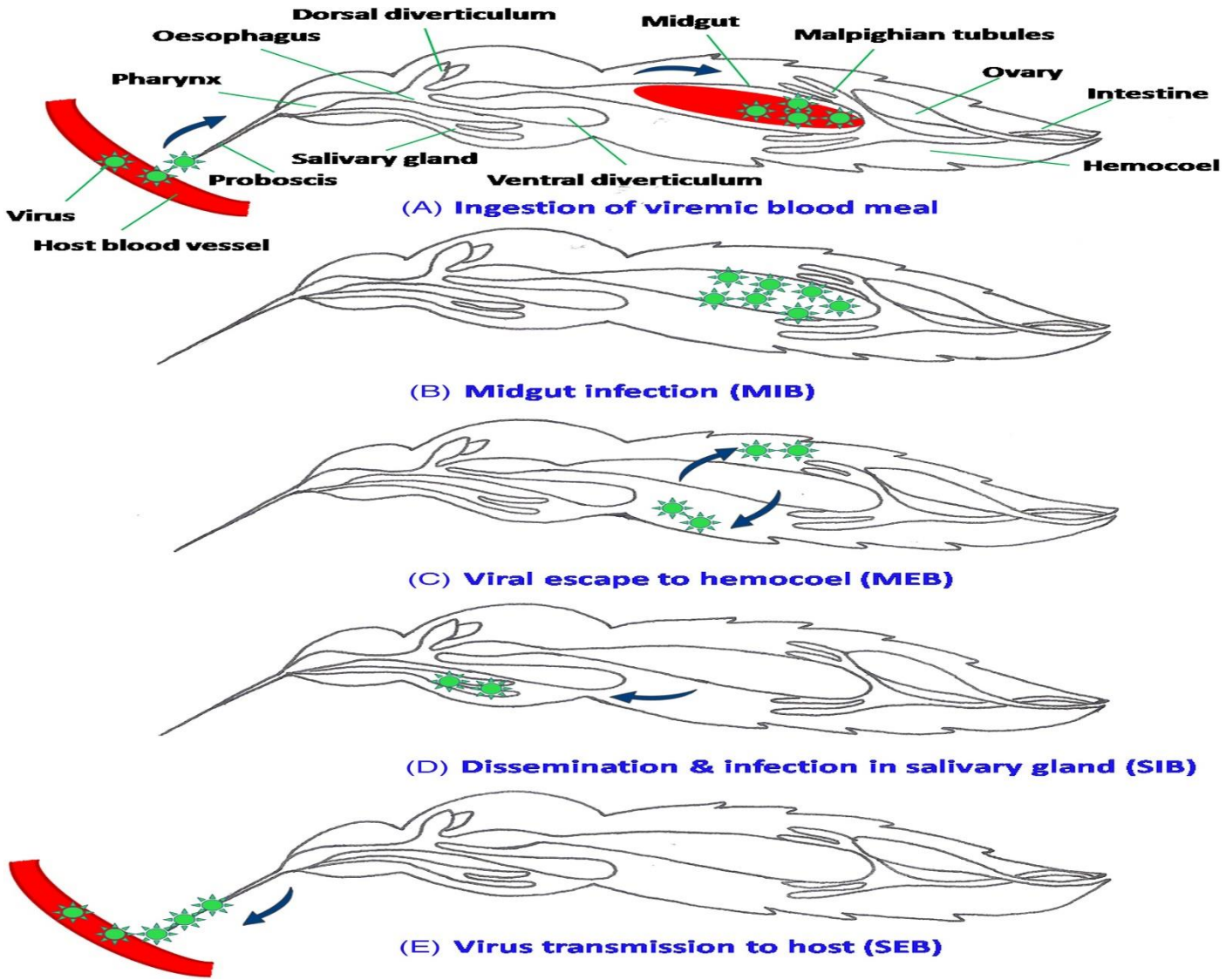


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Table 3 Reservoir hosts of human leishmaniasis in some endemic countries [8,24,27,35,36].

Region	Countries	Reservoir hosts
Old world	North Africa, central and west Asia	Dog, human, rodent
	Ethiopia, Kenya	Rodents, dog, domestic animals, bats, human, rock hyrax
	Indian subcontinent, (India, Nepal, Bangladesh) and east Africa	Dog, human, rock hyrax, rodent
	Mediterranean basin, central, west Asia and west Africa	Dog, fox, rodent, human
	Europe	Dog, fox
New world	Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominican, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Mexico, Nicaragua, USA, Venezuela, Paraguay, Peru, Surinam, Panama,	Dog, cats, rodent, marsupials, anteater, fox, monkey, coati, sloth, armadillo, porcupines, kinkajou, raccoon, red squirrel,

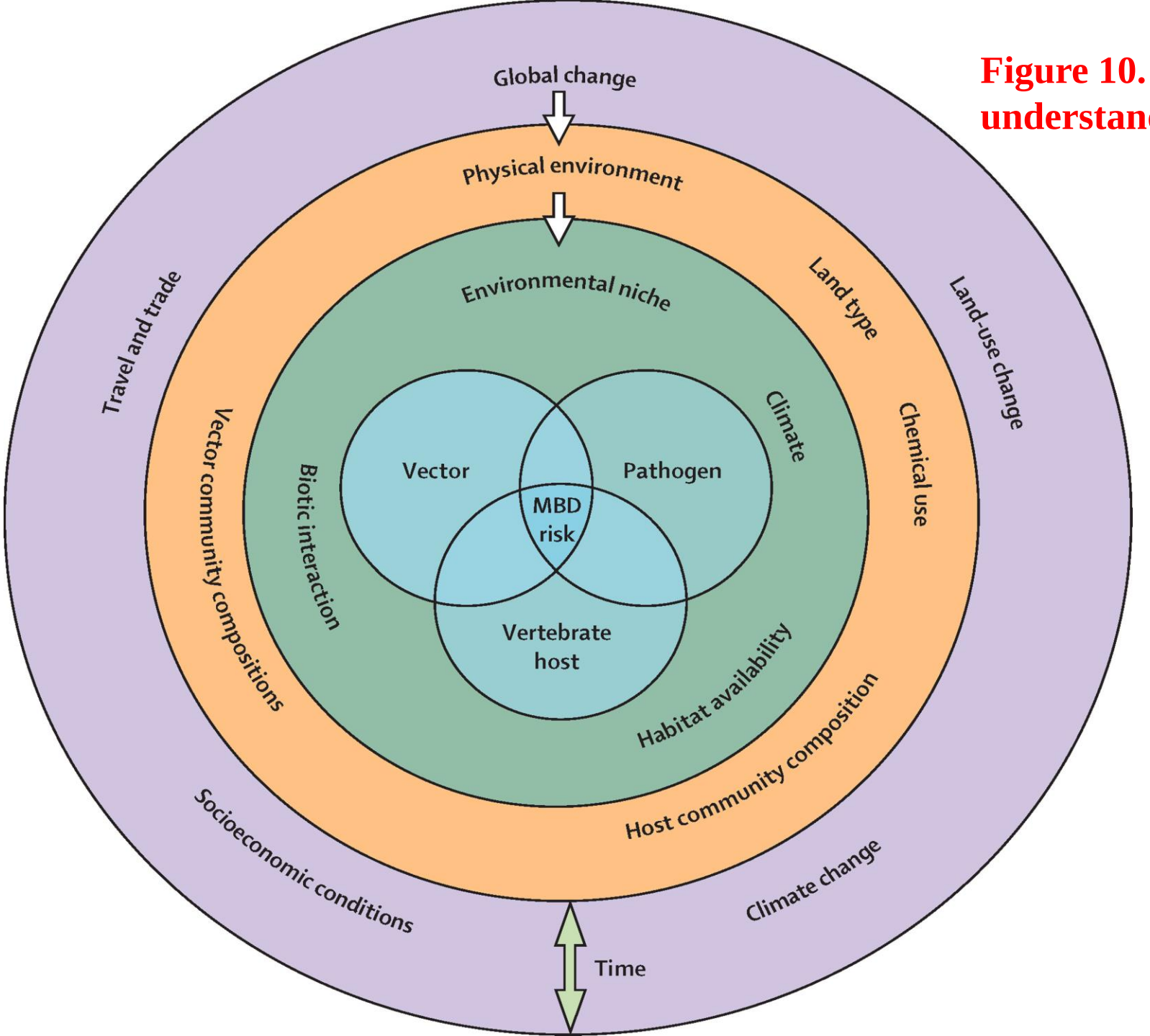

Figure 10. A system dynamics approach to understanding mosquito-borne disease risk

Figure 11. Percentage change in dengue cases and malaria deaths and annual mean land temperature change between 1993 and 2013

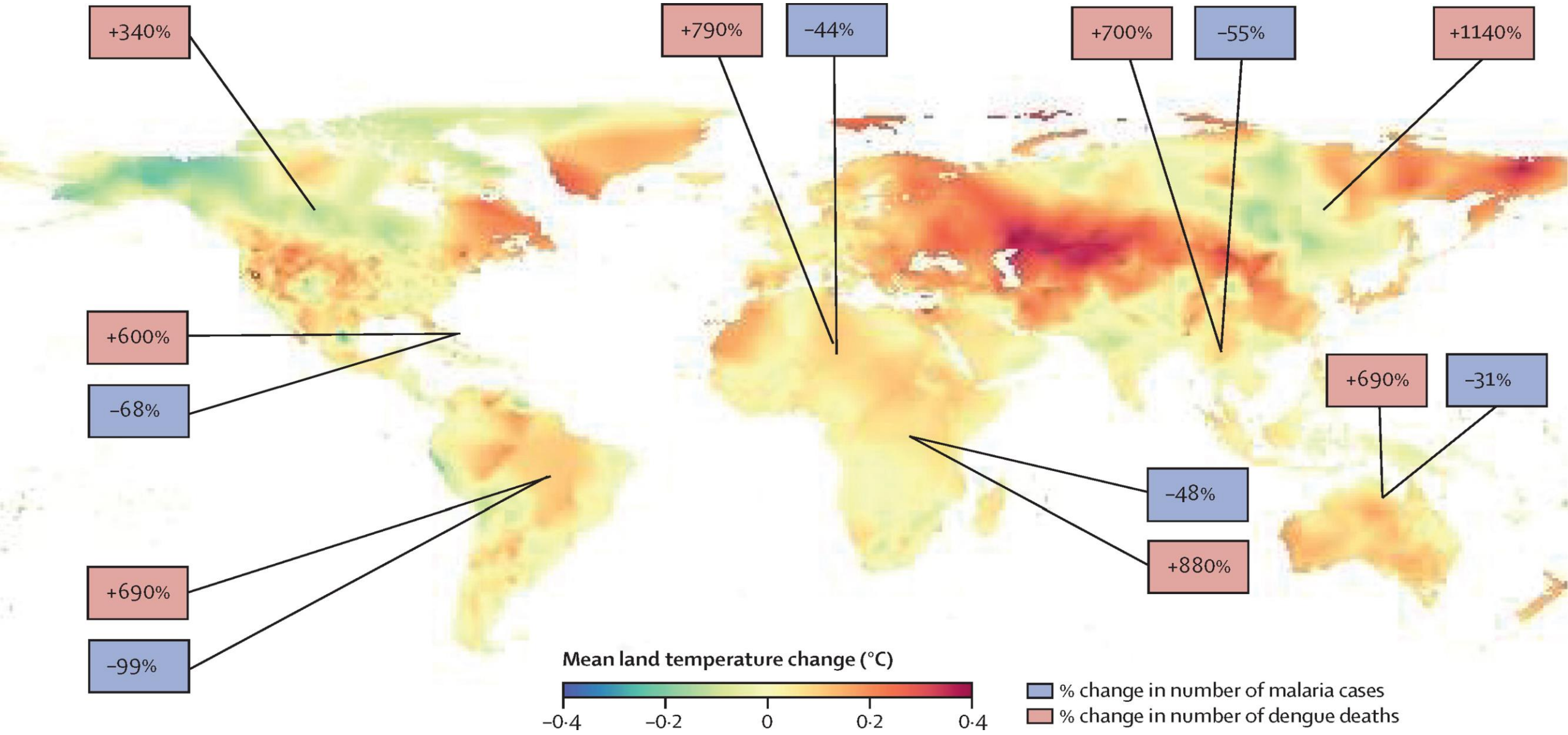

Figure 12. Possible impacts of climate change on changing risks from vector-borne diseases illustrated using possible impacts on Canada as an example

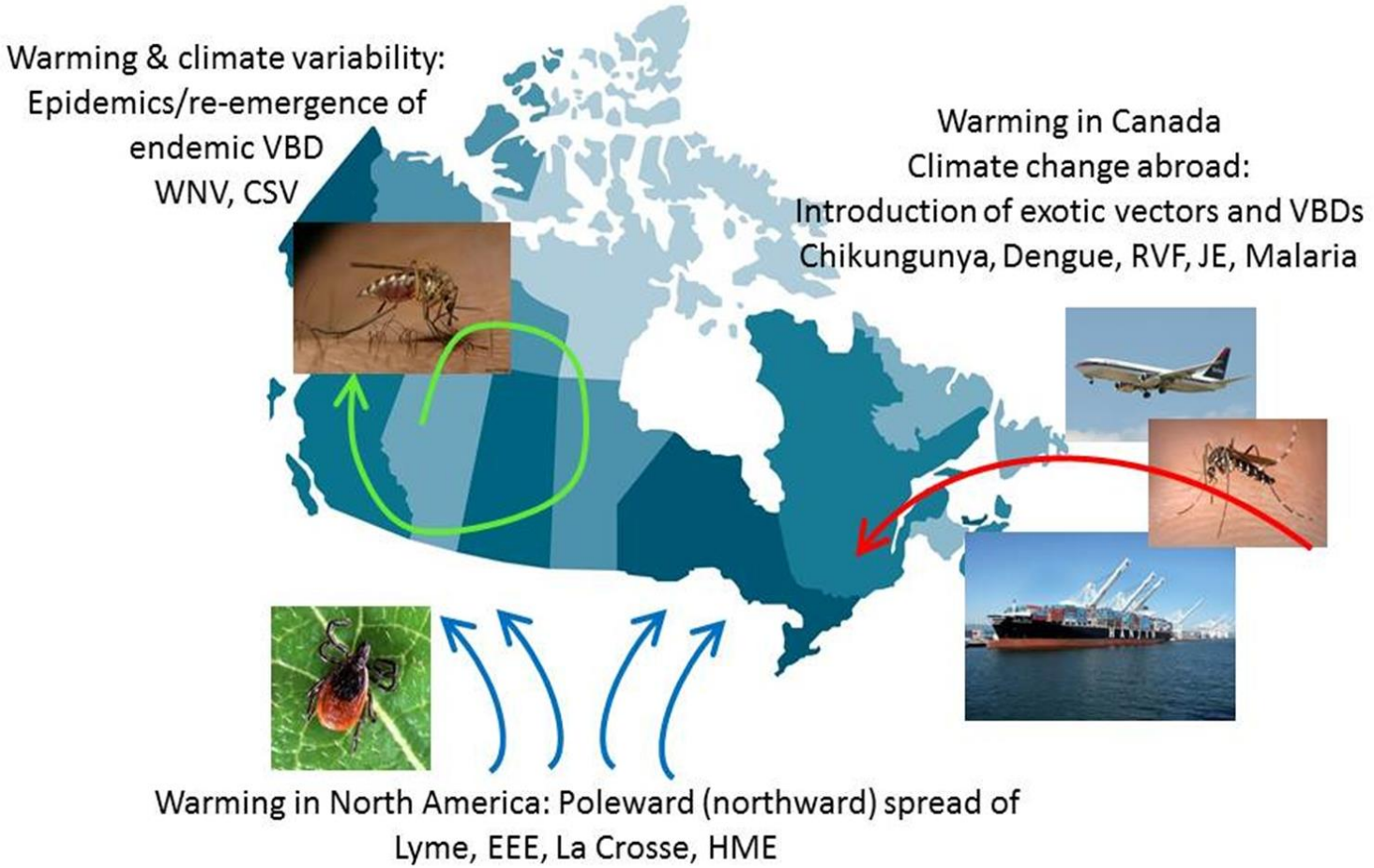

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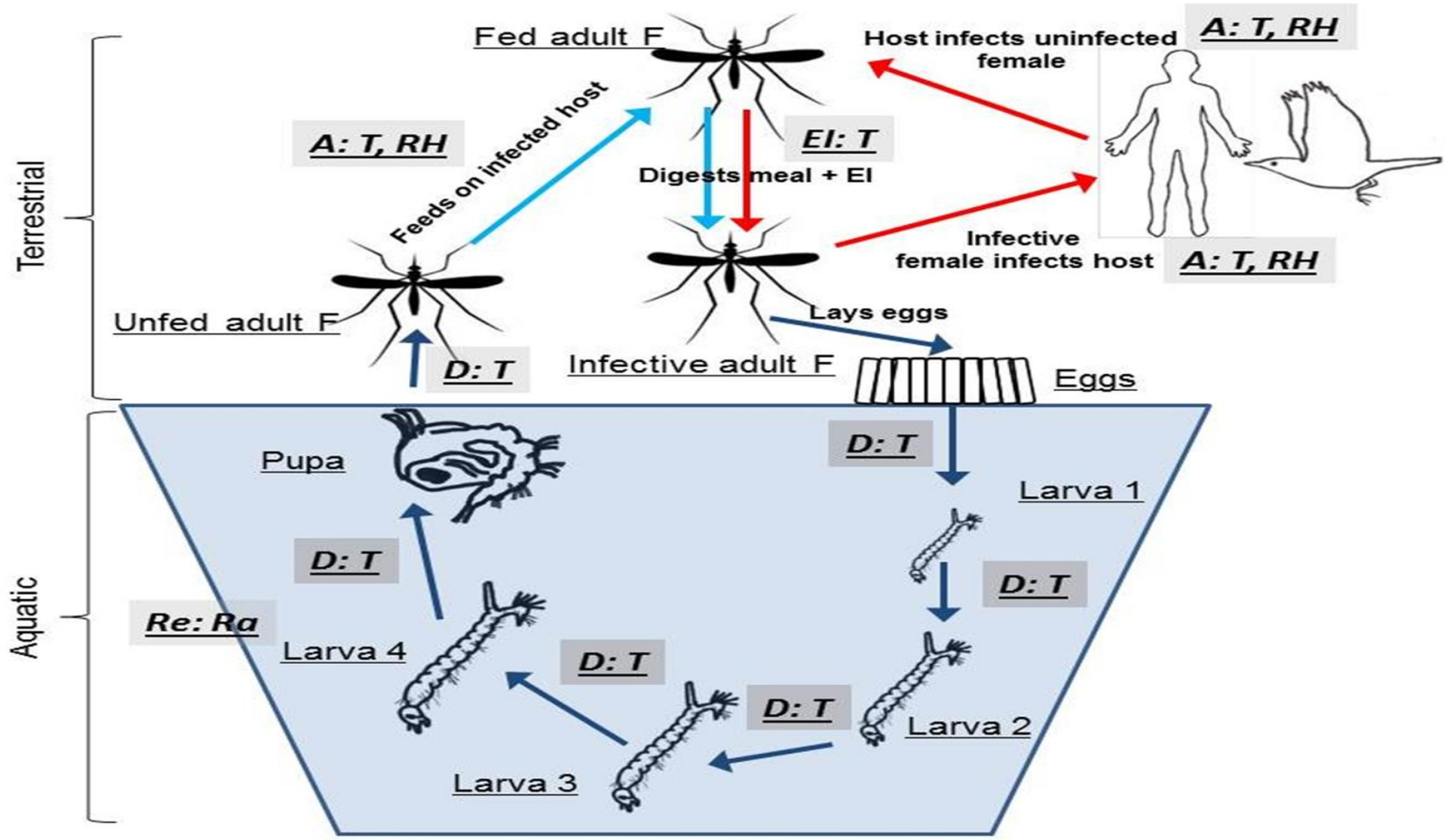
Figure 13. Direct effects of climate and weather on vector populations and vector-borne pathogen transmission illustrated by potential effects on West Nile virus transmission



FEMS Microbiol Lett, Volume 364, Issue 19, October 2017, fnx186, https://doi.org/10.1093/femsle/fnx186

Fig 14. A short history of vector control.

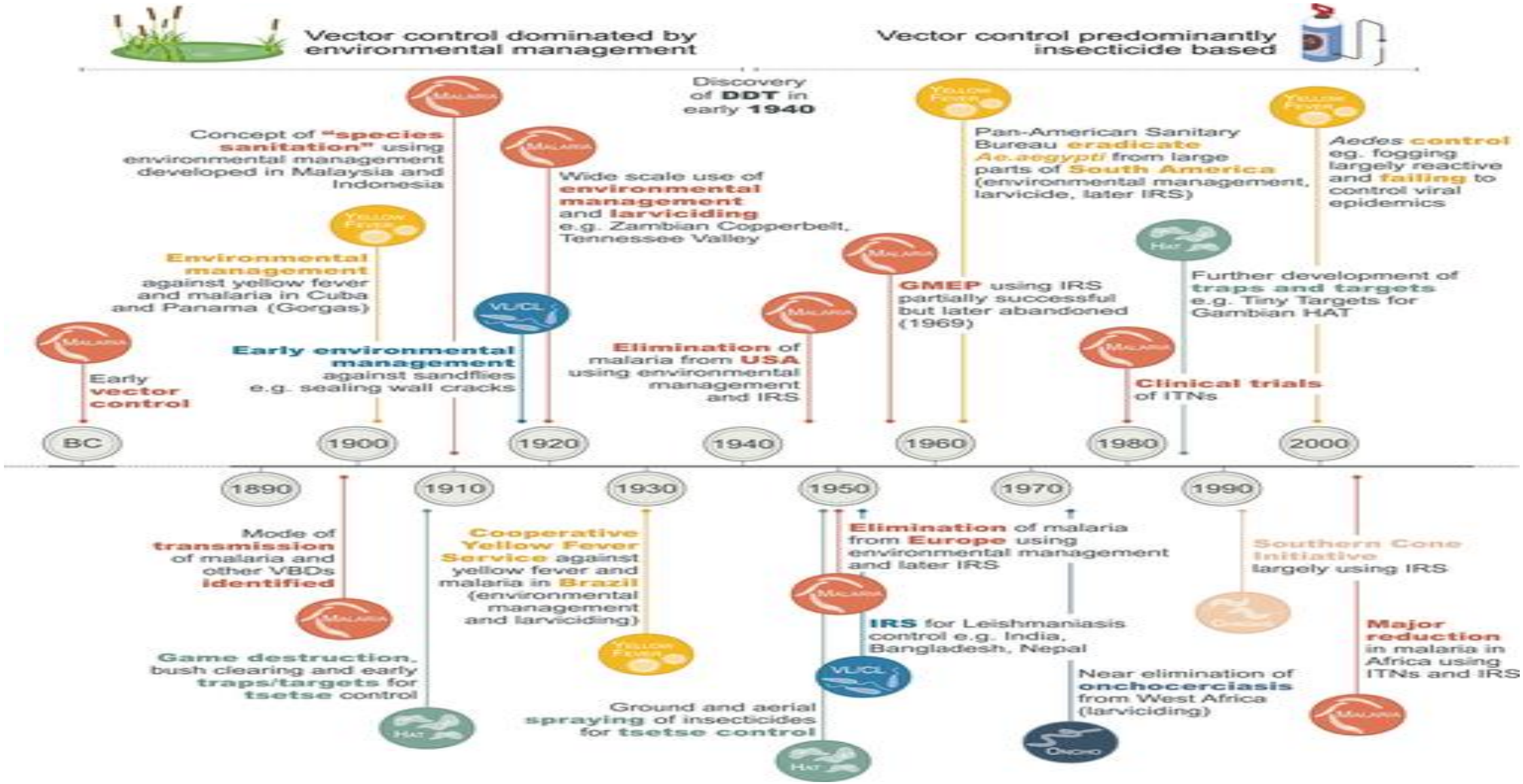


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Table 4. Categories and examples of vector control methods [11].

Chemical	Immature	Chemical larvicides	Contact pesticides affecting insect nervous system (e.g., temephos) or endocrine system (insect growth regulators, e.g., pyriproxyfen)
	Adult	ITNs	Pyrethroid-treated ITNs or combination ITNs (e.g., pyrethroid plus synergist piperonyl butoxide) for malaria, LF, and leishmaniasis control
		Insecticide-treated materials for personal protection	Insecticide-treated clothing for workers and mobile populations
		IRS	Spraying of residual insecticides (typically either pyrethroids, carbamates, or organophosphates) indoors for malaria and *Aedes*-borne disease control
		Space spraying	Aircraft, vehicle or hand-held space spraying for dengue epidemic and other *Aedes*-borne disease control
		Insecticidal treatment of habitat	Focal, perifocal, ground, or aerial insecticide spraying
		Insecticide-treated cattle	Pour-on or spot-on pyrethroids for control of tsetse
		Insecticide-treated traps and targets	Targets for control of HAT and insecticide-treated adulticidal oviposition traps for *Aedes*-borne diseases
		Topical repellent	Chemicals (e.g., N,N-diethyl-meta-toluamide [DEET], picaridin) applied to the skin to reduce vector biting
		Spatial repellent	Transfluthrin/metafluthrin passive emanators or coils
Nonchemical	Immature	Microbial larvicides	*Bacillus thuringiensis* var. *israelensis*, *B. sphaericus*
		Predator species	Predatory fish or invertebrates
		Habitat modification, i.e., a permanent change of land and/or water	Drainage of surface water, land reclamation and filling, and coverage of large water storage containers (or complete coverage of water surfaces) with a material that is impenetrable to mosquitoes, such as expanded polystyrene beads
		Habitat manipulation, i.e., a recurrent activity	Water-level manipulation, exposing habitats to the sun (depending on the ecology of the vector), flushing of streams, drain clearance, and source reduction, including rubbish disposal and regular emptying and cleaning of domestic containers (e.g., flowerpots, animal drinking water troughs)
		Regulatory measures	Removal of man-made aquatic habitats and appropriate waste disposal
	Adult	House improvement and screening	Closing eaves, door and window screening
		Removal trapping	Solar-powered mosquito trapping system for malaria control and sticky adulticidal oviposition traps for *Aedes*-borne diseases

Abbreviations: HAT, human African trypanosomiasis; IRS, indoor residual spraying; ITN, insecticide-treated bed net; LF, lymphatic filariasis

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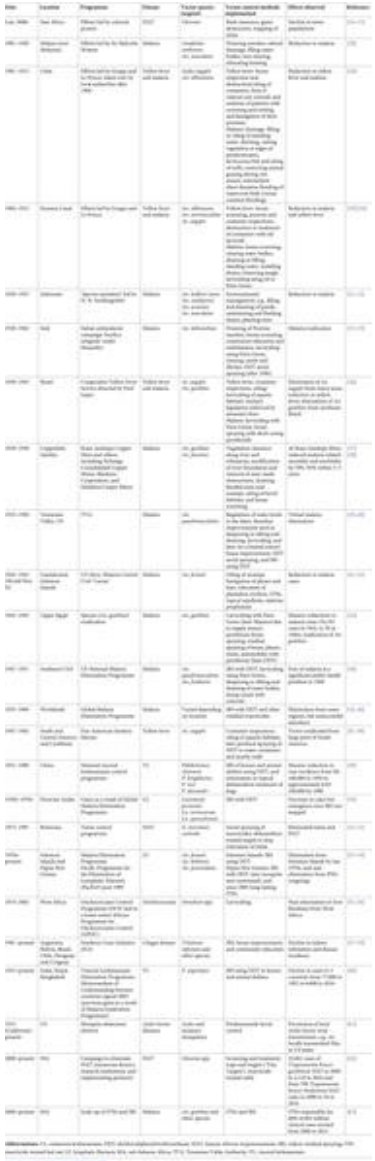
Table 5. Historical overview of notable vector control programmes and their effects.



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سپاس از حسن توجه شما