

OP-084 [Bee Biology]
Genetic Selection and Immune Mechanisms: A Scientific Approach to Enhancing Honeybee Resilience Against Viral Infections and Environmental Stressors

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Honeybees (*Apis mellifera*) play a critical role in global food production and biodiversity preservation. However, climate change, habitat degradation, and increasing pathogen virulence are driving unprecedented colony losses, threatening both beekeeping sustainability and agricultural stability. Traditional breeding techniques, primarily focused on single-trait selection for *Varroa destructor* resistance, have become insufficient in addressing modern challenges, particularly viral infections that contribute to colony immunosuppression. This study aims to develop a comprehensive genetic selection program that integrates viral resistance, immune system modulation, and colony resilience, providing beekeepers with a scientifically validated approach to improve honeybee health.

Problem Description:
Increased pathogenicity and virulence of honeybee diseases.
Reduction in plant biodiversity, limiting essential forage resources.
Unsustainable environmental and management costs for beekeepers.

Transmission pathways include queen-to-progeny vertical transmission, horizontal spread via *Varroa destructor*, contaminated food, and direct contact among bees. The complexity of viral co-infections, combined with the high level of social interaction within colonies, exacerbates disease spread and immunosuppression, placing extreme pressure on honeybee health.

Currently, no standardized selection criteria address viral resistance in breeding programs, making it challenging for beekeepers to choose resilient queen lines.

Methodology
An integrated breeding approach to improve honeybee resistance to viral infections through:
Selection of honeybee lines with enhanced immune responses, targeting virus-specific and broad-spectrum defense mechanisms; establishment of standardized diagnostic tools to assess queen health, reproductive viability, and colony resilience.

Data collection will involve controlled viral exposure trials, genetic and immunological profiling, and field assessments of selected colonies under diverse environmental conditions. A shared international database will be established to facilitate large-scale selection and breeding collaborations.

Results and CONCLUSION: Preliminary findings indicate that colonies selectively bred for enhanced immune function show increased tolerance to viral infections and overall improved health. By bridging scientific research and practical beekeeping needs, this program provides a transformative solution for beekeepers facing modern beekeeping challenges. Availability of genetically resilient bee lines, reducing dependence on chemical treatments.
Development of diagnostic tools to support breeding decisions and optimize colony renewal.
Reduction in colony losses and associated economic burdens. Increased pollination efficiency and agricultural sustainability. Establishment of an international selection network to facilitate shared breeding efforts.



GENETIC SELECTION FOR VIRUS RESISTANCE

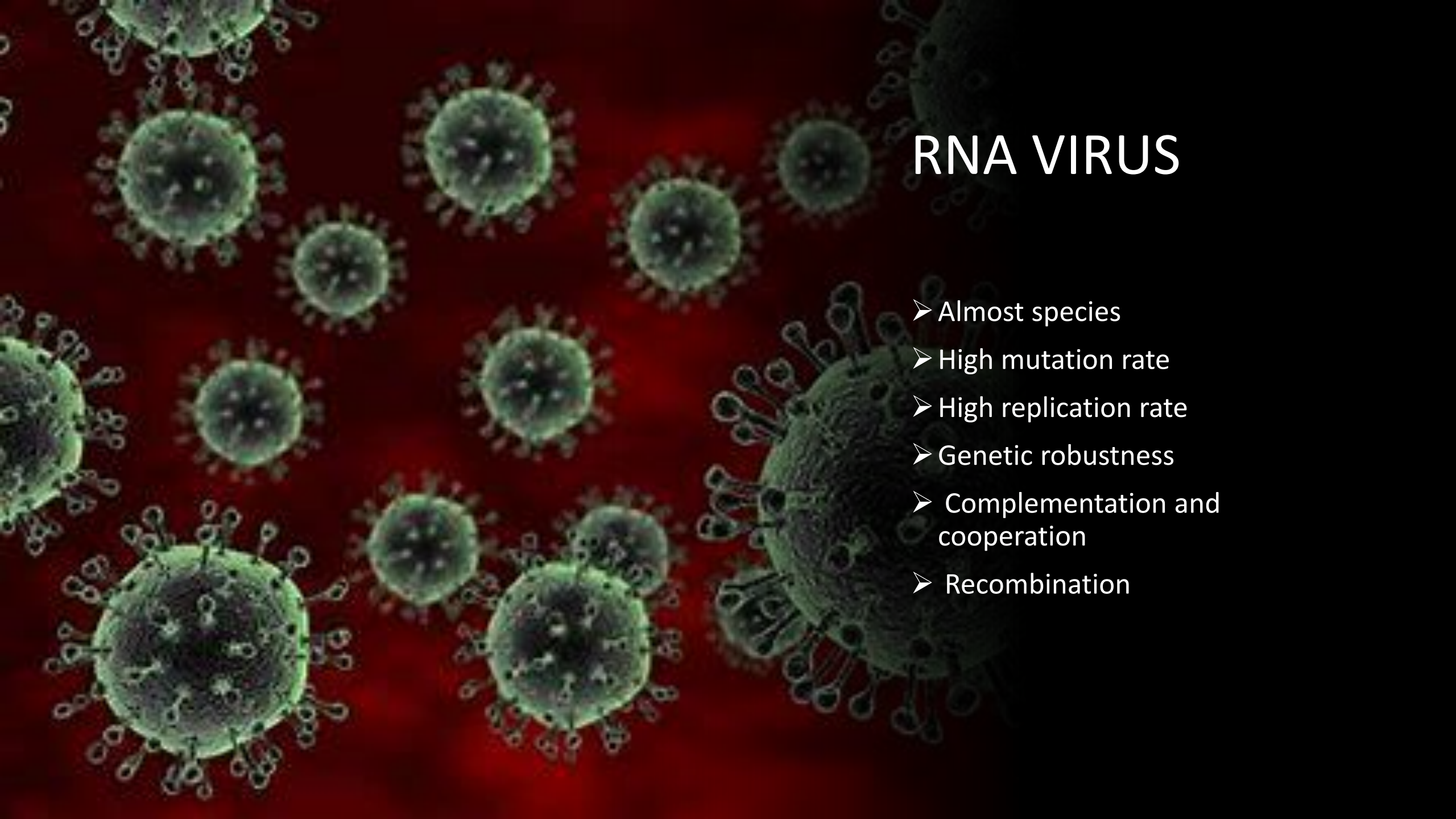
A necessary tool for bee health and the development of genetic selection in beekeeping

Giacomo Acerbi
49° Apimondia



WHAT ARE BEE'S VIRUSES?

- 72 Viruses detected in *Apis Mellifera*.
- Commensals, good viruses and real pathogens in a constantly evolving dynamic.
- Current relevance and future significance.



RNA VIRUS

- Almost species
- High mutation rate
- High replication rate
- Genetic robustness
- Complementation and cooperation
- Recombination

MEASURE OF DAMAGE

VIRULENCE

- Viral load
- Immune responses
- Biotic and abiotic factors
- Seasonality
- Recombination and coalition between multiple viral pathogens



SYMPTOMS

- Transmission routes
- Affected organs
- Tissue tropism
- Variants
- Age and different individuals of the colony

TRANSMISSION ROUTES: VERTICAL

- From progenitors to progeny



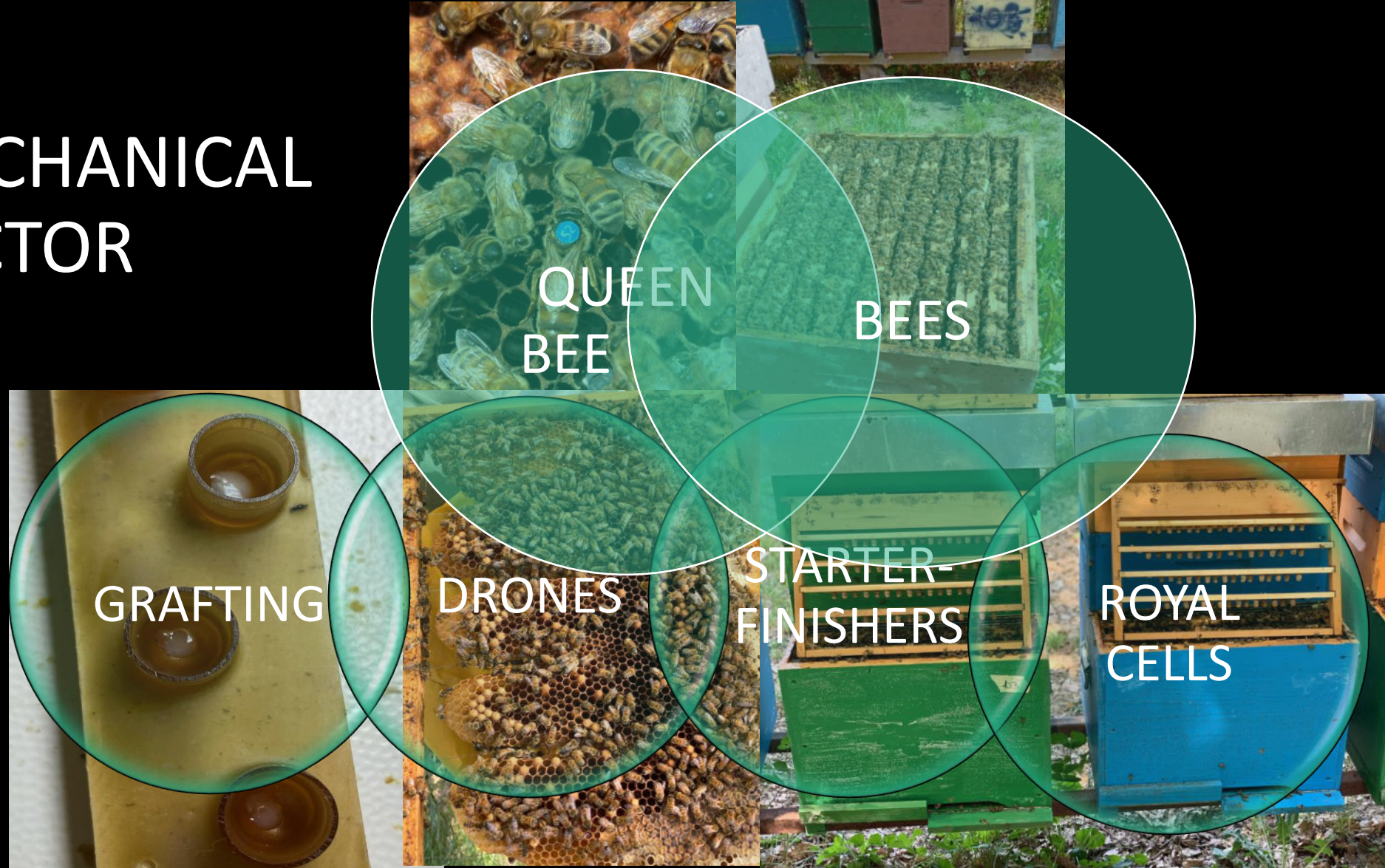
- Latent infections with hidden symptoms

HORIZONTAL

- Horizontal: contact, trophallaxis, nutrition, mating, environment.
- More virulent forms of the pathogen with overt symptoms and disease.



MECHANICAL VECTOR



Anthropogenic dispersal

LOOP OF CONTAGION

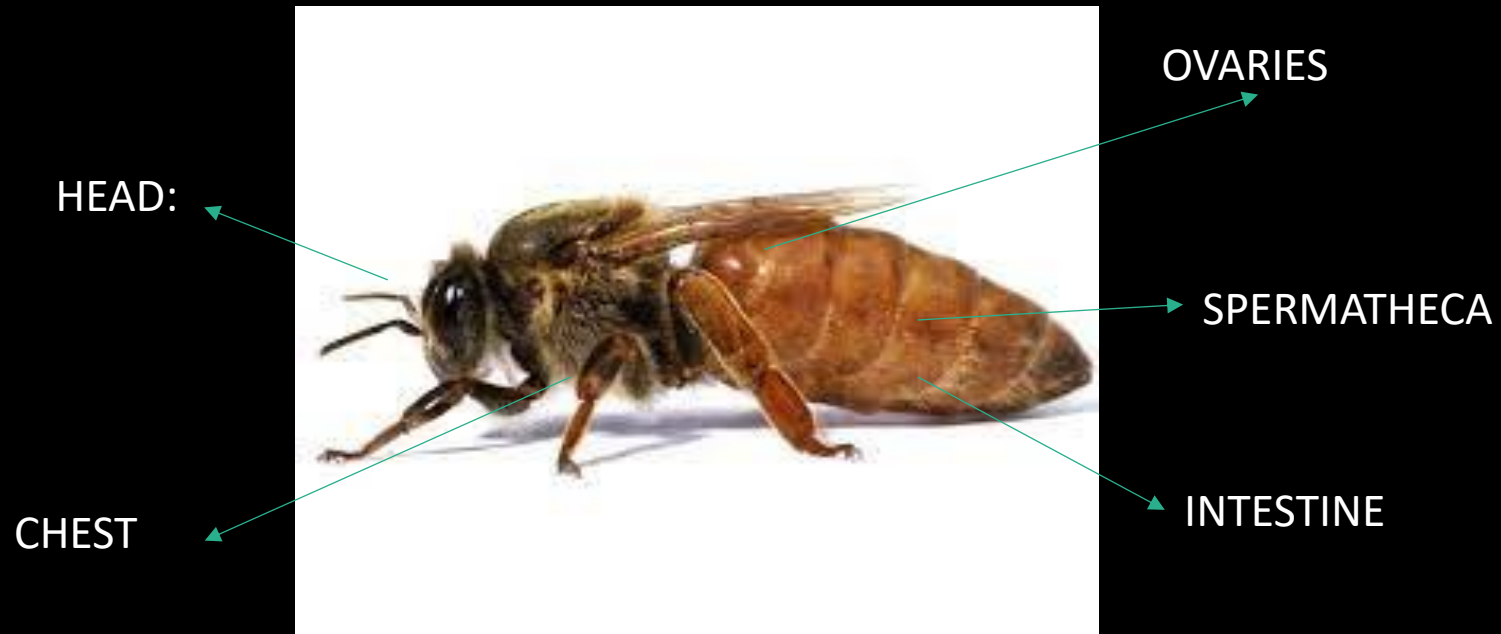
VERTICAL TRANSMISSION

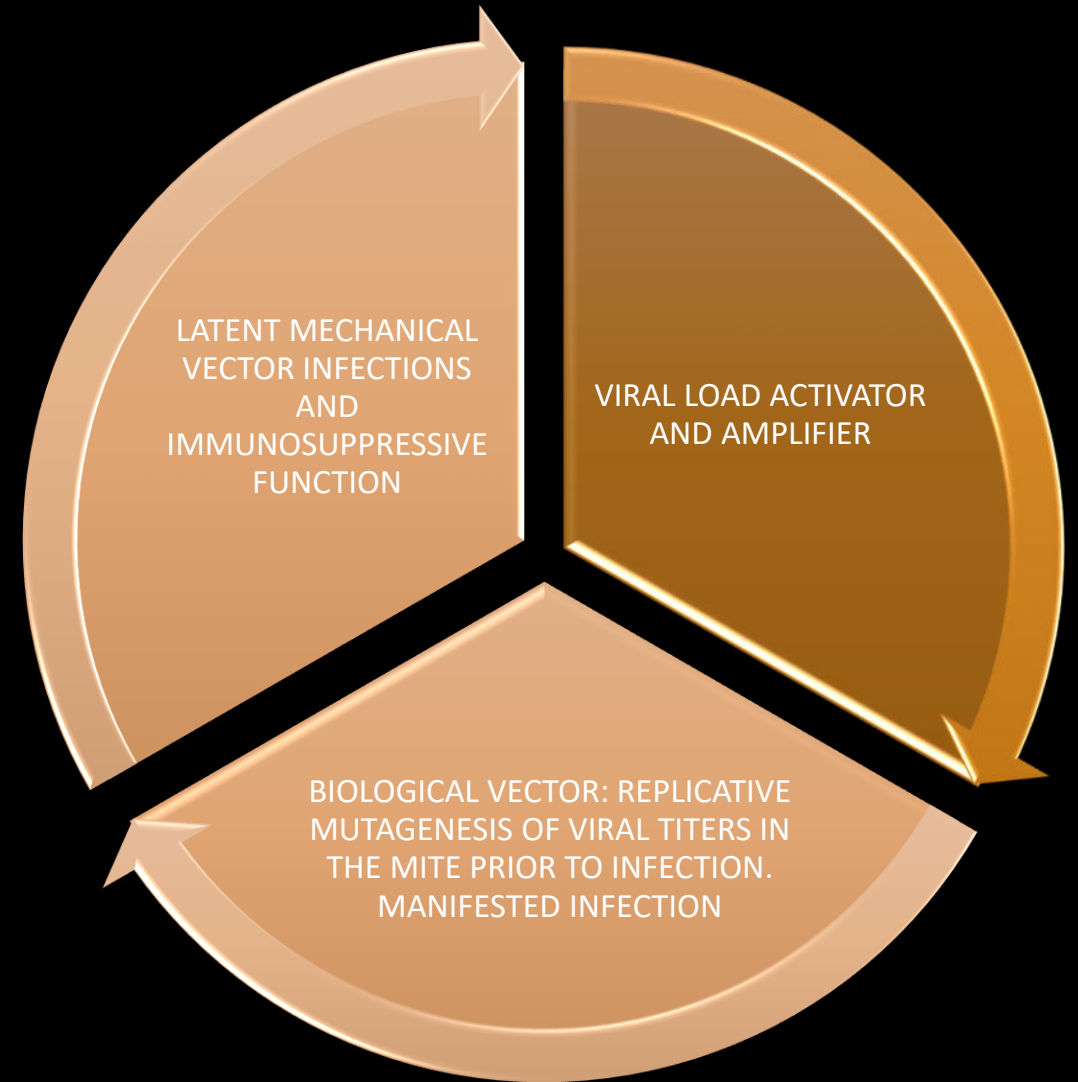
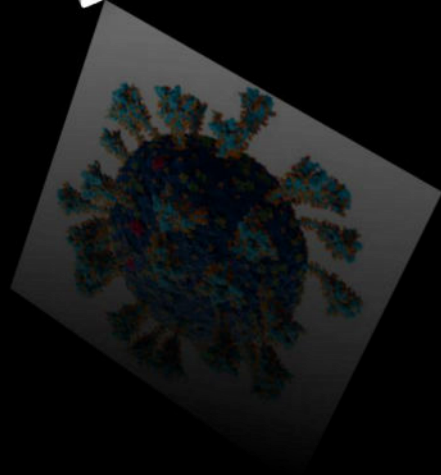
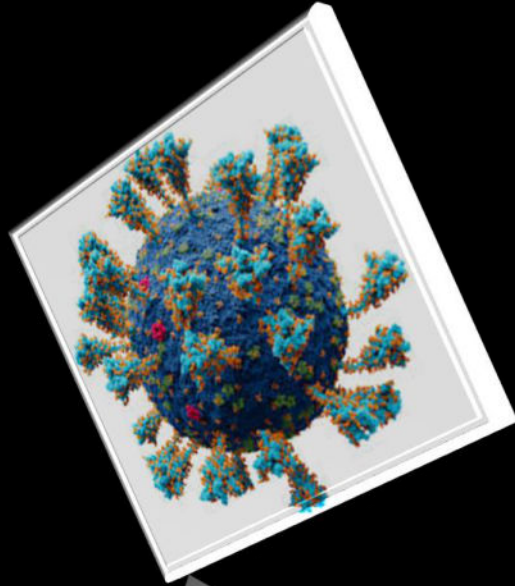
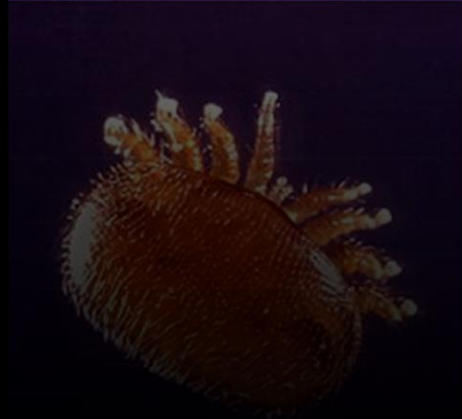
HORIZONTAL TRANSMISSION

VIRUSES ALREADY DETECTED IN EGGS

COUPLING
NUTRITION

- DVW
- SBV
- BQCV
- KBV
- CVPV
- IAPV
- LSV
- ABPV



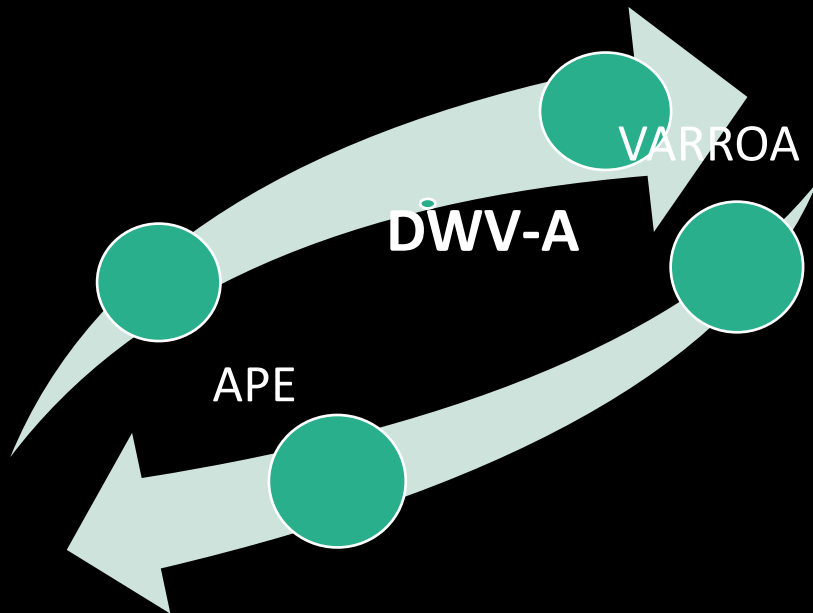


BEES/ VARROA /VIRUS

Varroa as a vector has increased the pathogenicity and virulence of DWV due to type of transmission and replication but:

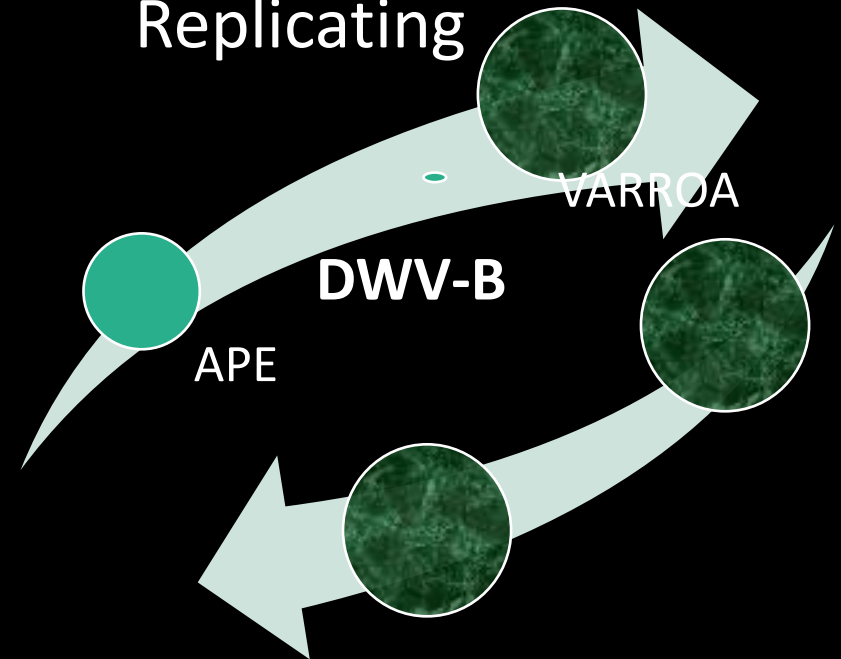
DWV-A

Conveyed in a non-propagative form

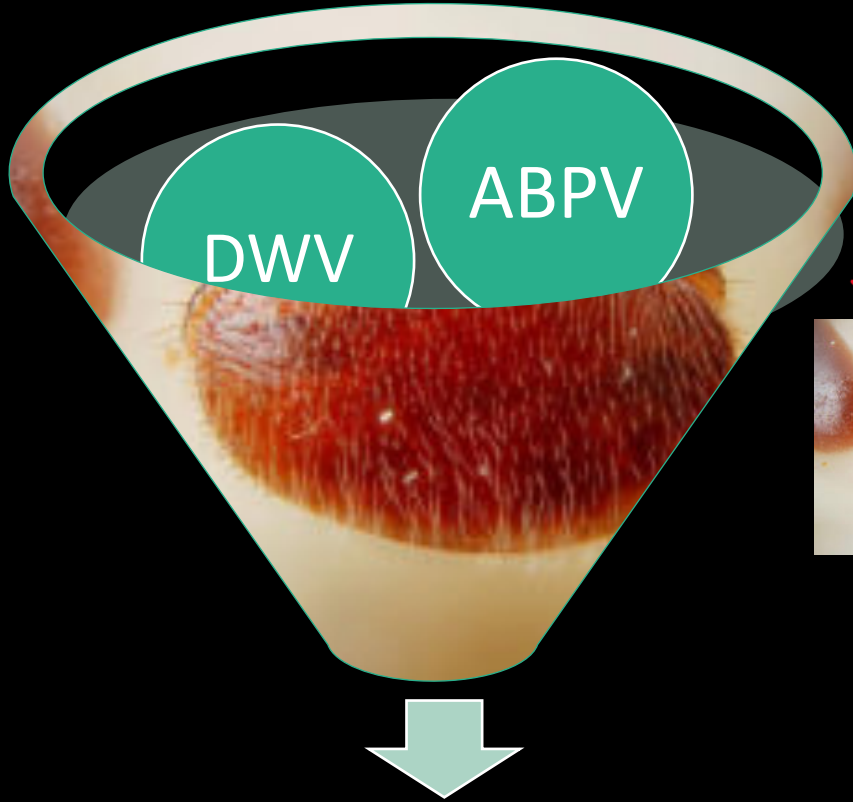


DWV-B

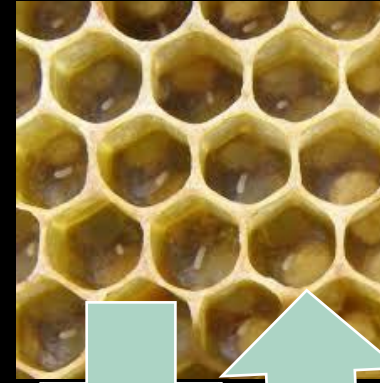
Replicating



BEEES/VARROA/VIRUS

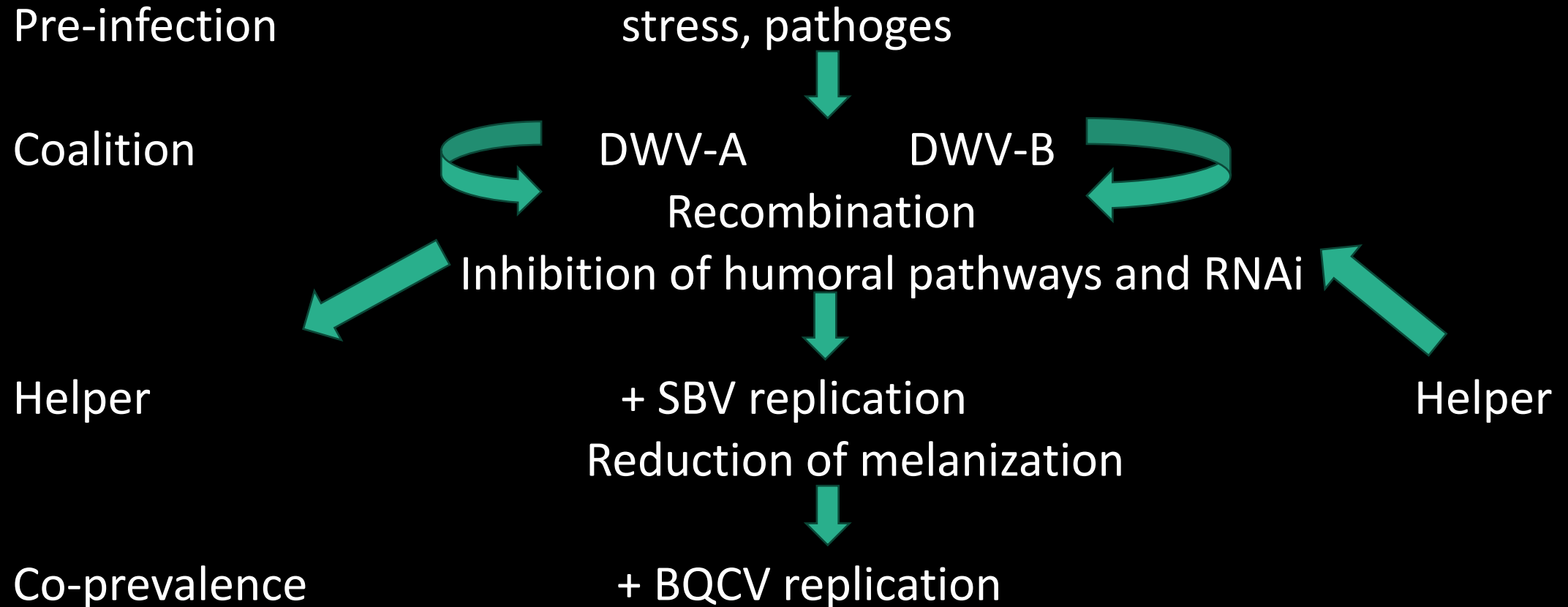


HIGHER VIRAL LOAD AND
ADAPTIVE VARIANTS



INCREASED VIRULENCE AND PATHOGENICITY

SUPERINFECTION



Routes of transmission - determine prevalence and virulence.



**LESS VARROA, MORE INCIDENCE OF VIRAL LOAD FEW BUT GOOD: INCREASE IN
VARROA GENOTYPES CAPABLE OF VIRAL REPLICATION AND MUTAGENESIS,
INCREASE IN VIRAL VARIANTS IN THE TRANSMITTED VIRAL POPULATION
THE DAMAGE CAUSED BY VARROA TO PUPA IS LINKED TO CERTAIN GENOTYPES
OF VARROA AND THE THRESHOLD OF RECENT CONTAGION**

bees/VARROA/VIRUS

- Quantitative damage threshold?
- Do resistant bee populations (VSH) survive only for control over the mite?
- Resistance traits vs. a parasite/active immune functions against a viral pathogen.
- Viruses replicate and cause damage even regardless of varroa.

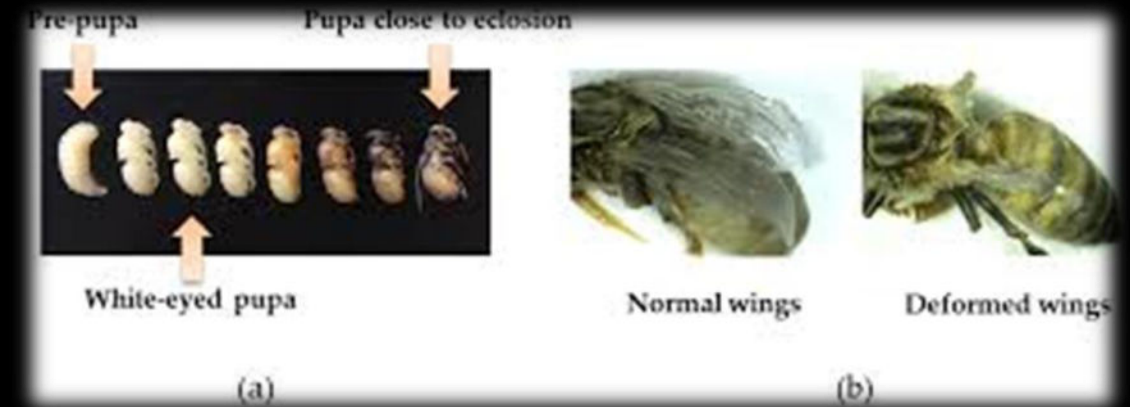


THE EVOLUTION OF THE STUDY OF HYGIENIC BEHAVIOR IN BEES

Selective hygiene behaviour

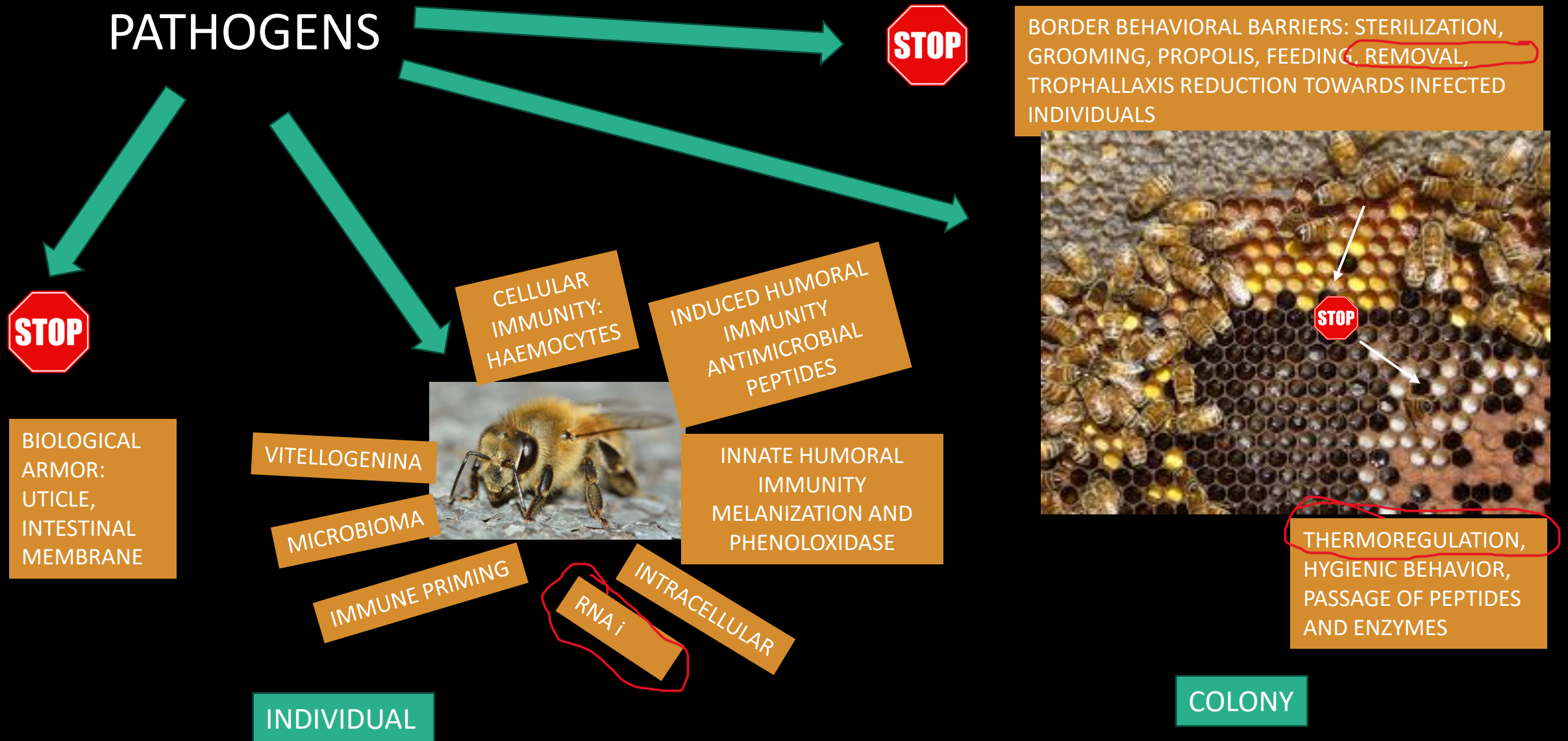
Hygienic bees more frequently recognize, uncap and remove brood parasitized by virulent mites, recognizing the chemical signals coming from the brood

Hygienic bees determine a negative selective pressure for Varroa genotypes more favorable to the replication of viral diseases

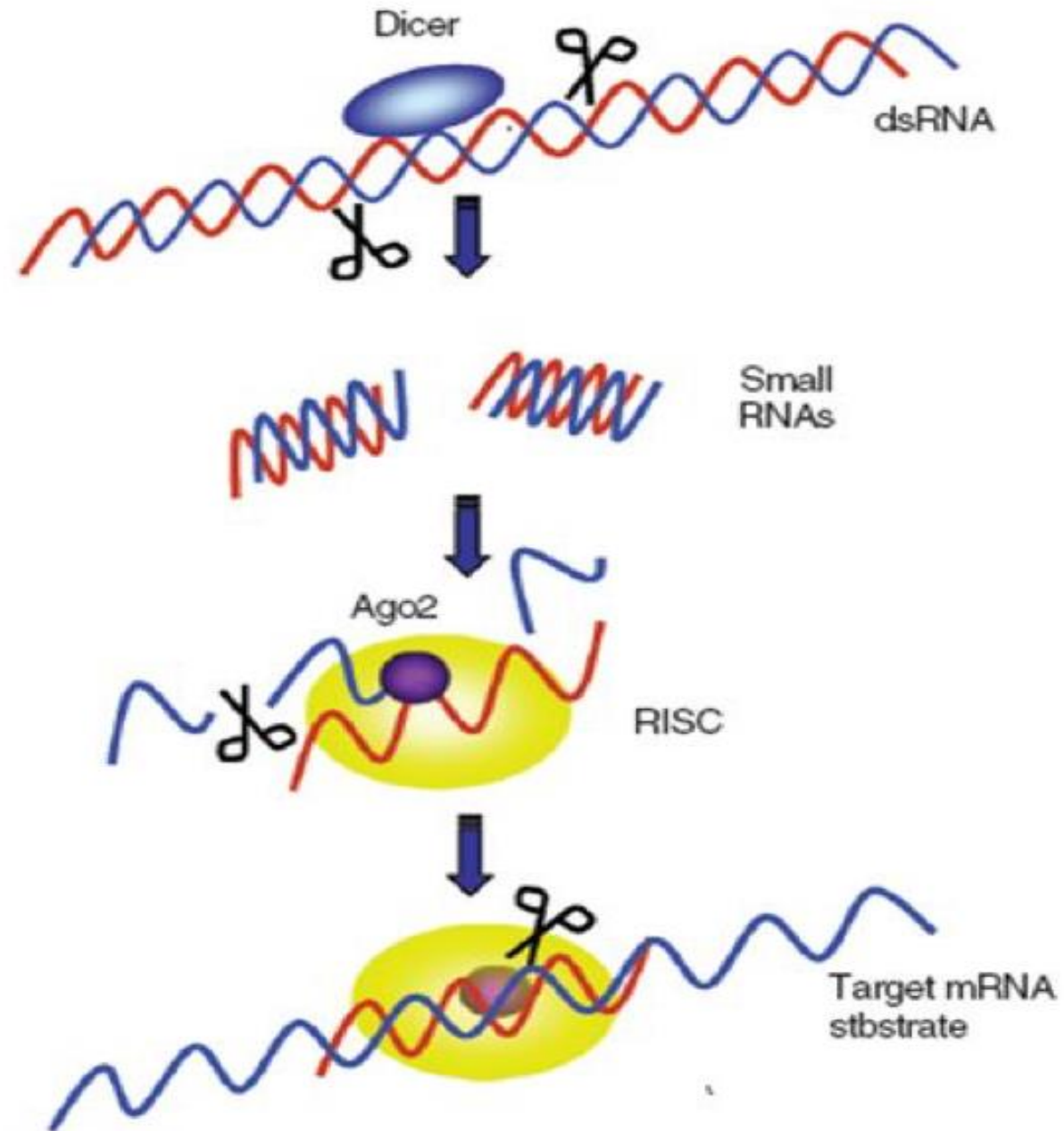


The principle of as much as necessary and as little as possible: limitation of removal behavior to pupae damaged by the viral load.

IMMUNE MECHANISMS OF BEES

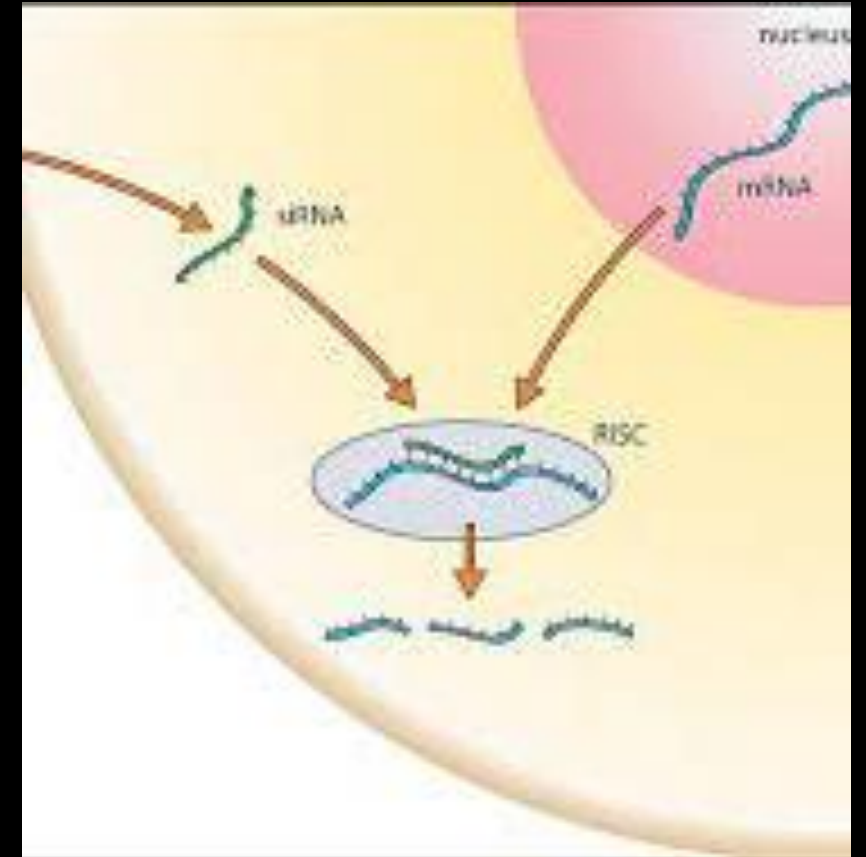


RISK



SOV – SUPPRESSED IN OVO VIRUS INFECTION

- SOV COLONIES = capable of limiting replication and reducing visceral virus virulence.
- In the egg the key to resilience to virus infection
- RNAi = control of viruses and inhibits replication, vertical transmission and promotes transgenerational triggering.



BEEES POPULATION RESISTANT TO VIRUS

SELECTED LINES WITH GENETIC INDEX

- Winter longevity – thriftiness
- VSH
- Hygiene

- Different environment
- Sister groups and half - sister groups

STANDARD DEVIATION

☒ Fecundity

RECUNDITY FERTILITY SPRING DEVELOPMENT

TIME BETWEEN START AND MAX EGG LAYING RATIO BEES BROOD EVOLUTION BEES

FIRST SUPPER MAINTAINING EGG LAYING EGG LAYING DURATION

OPTIMUM START LAYING PRECOCTY EGG LAYING ARREST

Gentleness and swarming

GENTLENESS SWARMING

Thriftiness

OVERALL WINTER SPRING SUMMER

Productivity

PRODUCTIVITY

Longevity

OVERALL WINTER SPRING RATIO BEES BROOD LONGEVITY FIRST DAYS

SUMMER

SELECTION PROTOCOL

BEE SAMPLES 2 TIME PER YEAR
FOR EACH HIVE



- COMPARISON SAMPLE IN THE SAME APIARY
- CHECK CORELATION WITH VARROA LOAD
- SISTER GROUPS IN DIFFERENT APIARY
- 10 DIFFERENT LINES



- DEFINITION OF THRESHOLD LIMIT FOR EACH VIRUS
- DEFINITION OF THRESHOLD LIMIT FOR HELPER AND CO-PREVALENCE VIRUS
- SEASONAL EVOLUTION OF THE VIRUS LOAD
- HERITABILITY IN THE PROGENY



GENETIC INDEX FOR VIRUS RESISTANCE



DIAGNOSIS AND QUANTIFICATION OF VIRAL LOAD

sample description	country	sampling date	arrival date	ABPV	BQCV	CBPV	DWV	SBV
Au_0244/BR_003	Austria	unknown	12/06/2024	0	849000	0	69200	0
Au_0274/BR_002	Austria	unknown	12/06/2024	0	1990000	0	129000	0
Au_0472/BR_004	Austria	unknown	12/06/2024	0	551000	0	63700	0
Au_0472/BR_005	Austria	unknown	12/06/2024	0	1970000	0	188000	0
Au_261/BR_006	Austria	unknown	12/06/2024	0	137000	8850	0	0
Au_0098/BR_010	Aust	unknown	12/06/2024	0	547000	0	66700	0
Au_0259/BR_007	Austria	unknown	12/06/2024	12200	1960000	6090	126000	0
Au_0263/BR_001	Aust	unknown	12/06/2024	0	4,7E+07	17400	116000	0
Au_0287/BR_008	Austria	unknown	12/06/2024	0	2150000	4430	0	0
Au_0468/BR_009	Aust	unknown	12/06/2024	0	3E+09	0	257000	0
It_668	Italy	09/09/2024	12/09/2024	0	253000000	0	162000000	1870000
It_542	Italy	09/09/2024	12/09/2024	0	2070000	8020	3E+11	32400
It_547	Italy	09/09/2024	12/09/2024	0	240000000	0	4700000	28200000000
It_267	Italy	09/09/2024	12/09/2024	193000	8,9E+09	1960	6,4E+11	491000
It_625	Italy	09/09/2024	12/09/2024	0	66500000	0	3760000	8020000
It_505	Italy	09/09/2024	12/09/2024	0	1,2E+09	3920	3110000	521000
It_505	Italy	09/09/2024	12/09/2024	0	5200000	0	6980000	56500
It_686	Italy	09/09/2024	12/09/2024	0	1,5E+07	0	6050000	1250000
It_511	Italy	09/09/2024	12/09/2024	0	568000000	0	76600000	828000
It_640	Italy	09/09/2024	12/09/2024	0	1,5E+07	0	1,4E+07	7310000
It_526	Italy	09/09/2024	12/09/2024	0	3210000	0	1990000	482000
It_271	Italy	09/09/2024	12/09/2024	0	4,2E+08	0	3130000	7,7E+08
It_549	Italy	09/09/2024	12/09/2024	0	3390000000	3560	195000000	20900
It_528	Italy	09/09/2024	12/09/2024	0	8780000	4290	2420000	8140000
It_501	Italy	09/09/2024	12/09/2024	0	8410000	2910	6000000000	5660
It_548	Italy	09/09/2024	12/09/2024	0	1,2E+07	0	7660000	10900

2024

Sample description	Country	Notes	ABPV result	Copy n°/bee	BQCV result	Copy n°/bee	CBPV result	Copy n°/bee	DWV result	Copy n°/bee	SBV result	Copy n°/bee
1041	Italy	-	positive	5,07E+06 positive		1,37E+09 positive		2,06E+06 positive		2,40E+07 positive		299000
2058	Italy	-	negative	0,00E+00 positive		8,16E+06 positive		2,57E+05 positive		8,50E+09 positive		56900
2323	Italy	-	negative	0,00E+00 positive		3,59E+07 negative		0,00E+00 positive		1,82E+05 positive		88500
2253	Italy	-	negative	0,00E+00 positive		1,22E+07 positive		2,89E+04 positive		5,79E+05 positive		130000
2242	Italy	-	negative	0,00E+00 positive		1,31E+08 positive		9,81E+04 positive		7,35E+05 positive		961000
2204	Italy	-	negative	0,00E+00 negative		0,00E+00 negative		0,00E+00 negative		0,00E+00 negative		0
1046	Italy	-	negative	0,00E+00 positive		1,44E+10 positive		3,77E+05 positive		9,67E+05 positive		315000
2159	Italy	-	positive	3,93E+05 positive		4,56E+08 positive		5,96E+05 positive		8,79E+07 positive		2600000
2405	Italy	-	negative	0,00E+00 positive		2,81E+09 positive		1,63E+10 positive		8,01E+10 positive		27700000
2206	Italy	-	negative	0,00E+00 positive		2,17E+05 positive		2,80E+04 negative		0,00E+00 negative		0
2293	Italy	-	negative	0,00E+00 positive		9,01E+08 positive		3,57E+06 positive		4,82E+10 positive		3,78E+08
2258	Italy	-	negative	0,00E+00 positive		3,55E+04 positive		6,83E+04 positive		5,82E+04 negative		0
2162	Italy	a	negative	0	positive	22600000	positive	220000	positive	1080000	positive	2,32E+09
1043	Italy	-	positive	2,53E+06 positive		2,88E+07 positive		2,41E+06 positive		3,18E+07 positive		4,94E+08
2088	Italy	-	negative	0,00E+00 positive		3,32E+07 positive		1,32E+05 positive		7,58E+05 positive		1,2E+09
1049	Italy	-	negative	0,00E+00 positive		2,26E+07 positive		3,82E+07 positive		2,87E+06 positive		114000
1044	Italy	-	positive	9,10E+06 positive		1,69E+08 positive		5,44E+07 positive		6,32E+06 positive		2980000

2025

COLONY IMMUNOSUPPRESSION SYNDROME

