

How science supports honey bees: Identification of research on best practices in beekeeping

Kristina Gratzner, Veronika Musalkova, Robert Brodschneider

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Science has advanced our understanding of honey bees in many areas, particularly in disease management and treatment. But what research has been published, possibly supporting beekeepers in decision-making on their own colonies? To answer this, we conducted a literature study of English language, peer-reviewed papers published since 1995. Inclusion criteria required studies to focus on honey bee colonies (excluding caged bee experiments or laboratory studies) and present field research with control and experimental groups. Out of 341 reviewed papers, 191 met these criteria, documenting 744 distinct beekeeping practices. We extracted, among others, the following information from these studies: Topic (from a pre-defined list), geographic origin of study, species and subspecies covered, and whether the respective practice had positive or negative impacts on measured parameters. The majority of identified practices (57.0%) addressed the management of Varroosis, followed by practices related to General Apiary Management (17.2%), American Foulbrood (9.7%), Tropilaelaps (8.7%), and Aethinosis (4.6%). Geographically, most research was conducted in the USA (26.9%), followed by Italy (9.1%), Argentina (5.1%), Canada (5.1%) and Pakistan (4.6%). The primary study species was *Apis mellifera* and its subspecies, with only 0.1% of practices relating to *Apis cerana*. Among the practices with a positive impact on Varroa reduction (n = 177), oxalic acid (21.5%) was most frequently cited, followed by tau-fluvalinate (11.3%) and formic acid (10.7%). Biotechnical methods, such as drone brood removal and queen caging, were also effective. For American foulbrood, shook swarms were the primary method for spore reduction (69.2%) and colony recovery (29.1%). Additionally, General Apiary Management practices, including starting new colonies, comb management, and using domestic queens, improved colony survival and honey yields. Our findings provide an overview of key areas of honey bee health research and effective beekeeping practices, offering evidence-based insights for improving honey bee health and apiary management and supports worldwide decision-making in apiculture.



UNIVERSITY OF GRAZ



What has science done for beekeeping?

Kristina Gratzner
with: Veronika Musalkova
Robert Brodschneider

Department of Biology
Honey bee, Environment & Society

Apimondia, Copenhagen, 2025

Tradition vs. Evidence

Past

Knowledge mainly from daily practice and through beekeeping community

Present

Knowledge is expanded by scientific evidence



...still people remain sceptical...



**What has science done for
beekeeping?**



Lab studies are important, but not applicable in daily beekeeping life

Fellows et al. *Virology Journal* (2023) 20:134
<https://doi.org/10.1186/s12985-023-02104-0>

Virology Journal

RESEARCH

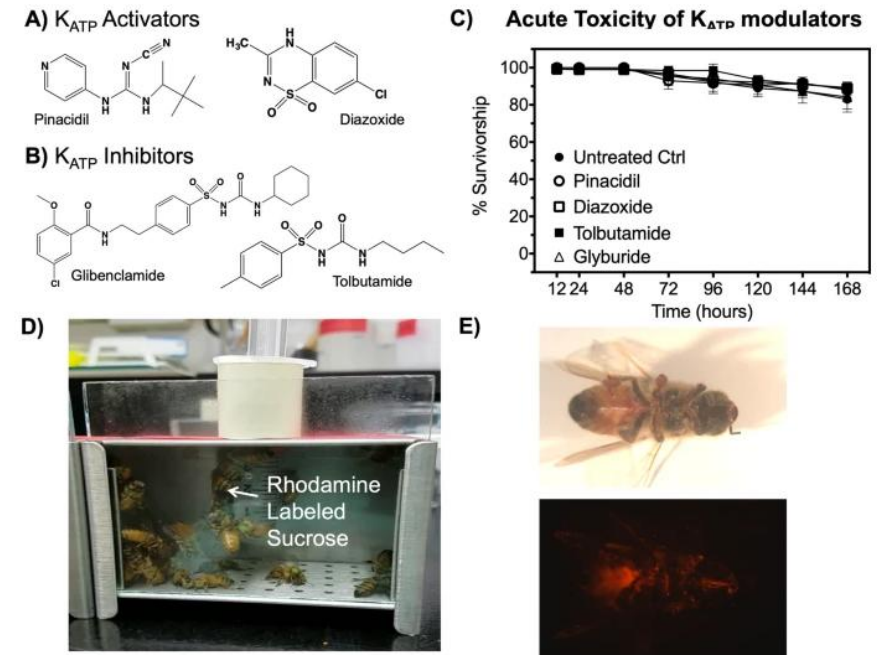
Open Access

Potassium ion channels as a molecular target to reduce virus infection and mortality of honey bee colonies

Christopher J. Fellows¹, Michael Simone-Finstrom², Troy D. Anderson³ and Daniel R. Swale^{1,4*}



Fig. 1



Structures of K_{ATP} modulators and their toxicity to bees. K_{ATP} channel activators (A) and inhibitors (B) used in this study. C Toxicity of K_{ATP} modulators to honey bees. Data points represent percent mean ($n = 5$, 50 bees per replicate survivorship with error bars representing SEM. D Image of caged bees with sucrose solution containing Rhodamine B and chemical modulators. E Representative image of bees under white and fluorescent light that verify individuals fed on the chemical treated solution

Beekeeping needs turned into solutions

PLOS ONE

RESEARCH ARTICLE

Honey bee hive covers reduce food consumption and colony mortality during overwintering

Ashley L. St. Clair^{1*}, Nathanael J. Beach^{1,2}, Adam G. Dolezal^{1,2}

¹ Department of Entomology, University of Illinois Urbana-Champaign, Urbana, Illinois, United States of America, ² Carl R. Woese Institute for Genomic Biology, University of Illinois at Urbana-Champaign, Urbana, Illinois, United States of America

Journal of Insect Science, (2023) 23(6): 14; 1–5
<https://doi.org/10.1093/jisesa/iead085>
Research



ENTOMOLOGICAL
SOCIETY OF AMERICA
SHARING INSECT SCIENCE GLOBALLY

OXFORD

Inducing a summer brood break increases the efficacy of oxalic acid vaporization for *Varroa destructor* (Mesostigmata: Varroidae) control in *Apis mellifera* (Hymenoptera: Apidae) colonies

Jennifer A. Berry^{1,*}, S. Kris Braman^{1,*}, Keith S. Delaplane^{1,*}, Lewis J. Bartlett^{1,2,*}

¹Department of Entomology, University of Georgia, Athens, GA 30602, USA, ²Center for the Ecology of Infectious Diseases, Odum School of Ecology, University of Georgia, Athens, GA 30602, USA *Corresponding author, mail: jbee@uga.edu

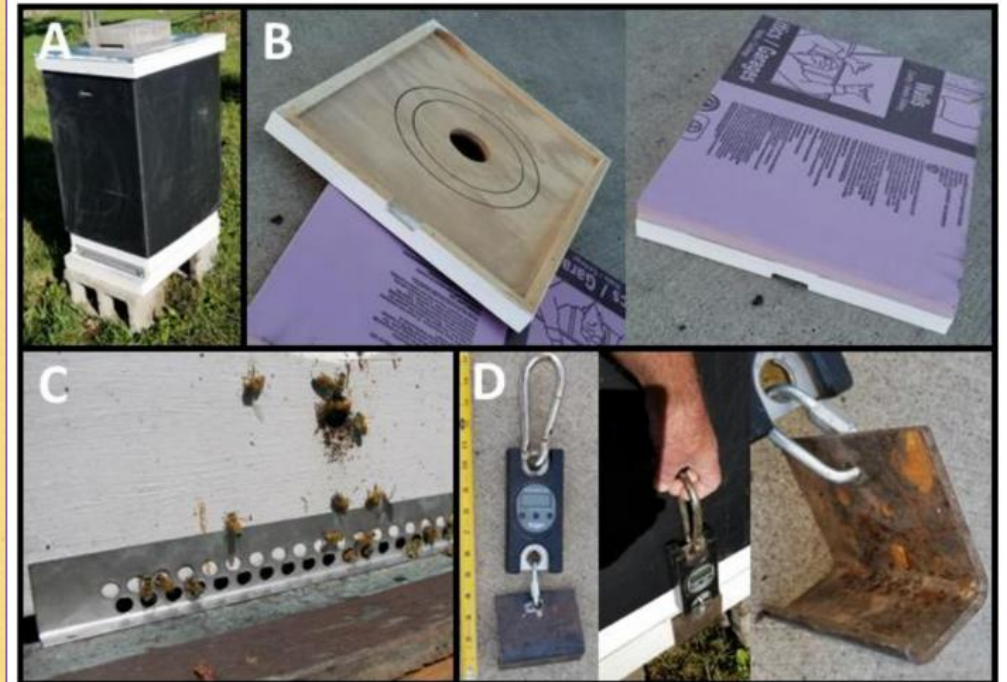


Fig 2. (A) Polypropylene hive cover on a honey bee colony. (B) Inner cover board and insulation that are placed on the top of the hive under the polypropylene cover. (C) Mouse guard on entrance to reduce rodent infestations. (D) Modified postal scale used to weigh colonies.

<https://doi.org/10.1371/journal.pone.0266219.g002>

What has science done for beekeeping?

01

Historical research

A century of discovery: Mining 100 years of honey bee research

Edgar E. Hassler , Joseph A. Cazier , Brandon Hopkins, James T. Wilkes , Kiefer Smith & Max Rünzel

Pages 3-12 | Received 06 Oct 2018, Accepted 13 Apr 2020, Published online: 03 Aug 2020

 Cite this article  <https://doi.org/10.1080/00218839.2020.1794303>



- 1917-1940s Bee vision
- 1950s Commercial beekeeping
- 60s problems with pesticides
- 70s hormones/pesticides/populations
- 80s killer bees
- 90s Varroa mites
- 2000-2004 Brain games
- 2005-2009 Genetic age
- 2010-2014 Colony collapse disorder

(Hassler et al. 2020)

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01a Much research on honey bees, but...

01b ...does it reach the apiary?

02 Hive manipulations ready to use in the field

03 Research paper supported decision-making for vets, beekeepers, advisory

-> Literature filter, contradicting research and research gaps, ...

Method of meta-analysis (1)

01 We aimed to obtain the widest possible collection of peer-reviewed scientific original articles on best practices in beekeeping.

02 Criteria:

- field studies
- experimental & control groups
- full colonies (no caged bee studies)
- no surveys or review articles
- publication date: 1995–2023

Search



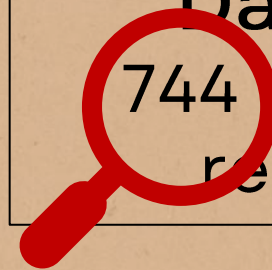
Screening
341 papers



Inclusion
191 papers



Dataset
744 practice records



Method of meta-analysis (2)

Categorization of practices

(Pietropaoli & Formato 2019; Pietropaoli et al. 2020)

- Origin of practice
- Month of application
- Impact  
- Honey bee species
- Number of colonies

.....

Category	Themes	Sub-themes
Good beekeeping practice	General apiary management	Colony management Feeding and Watering Hygiene Queen management
Good beekeeping practice Ergebnis		
Biosecurity measures	Aethinosis	*"Soft" acaricides Breeding for resistance Colony management Hive entrance modification In-hive traps Traps outside of hives
	AFB	Antibiotics Biotechnical methods Biotechnical methods + antibiotics Breeding for resistance Colony management Laboratory testing Organic agents Stamping-out Vaccination
	Chalkbrood	Breeding for resistance
	EFB	Antibiotics Biotechnical methods

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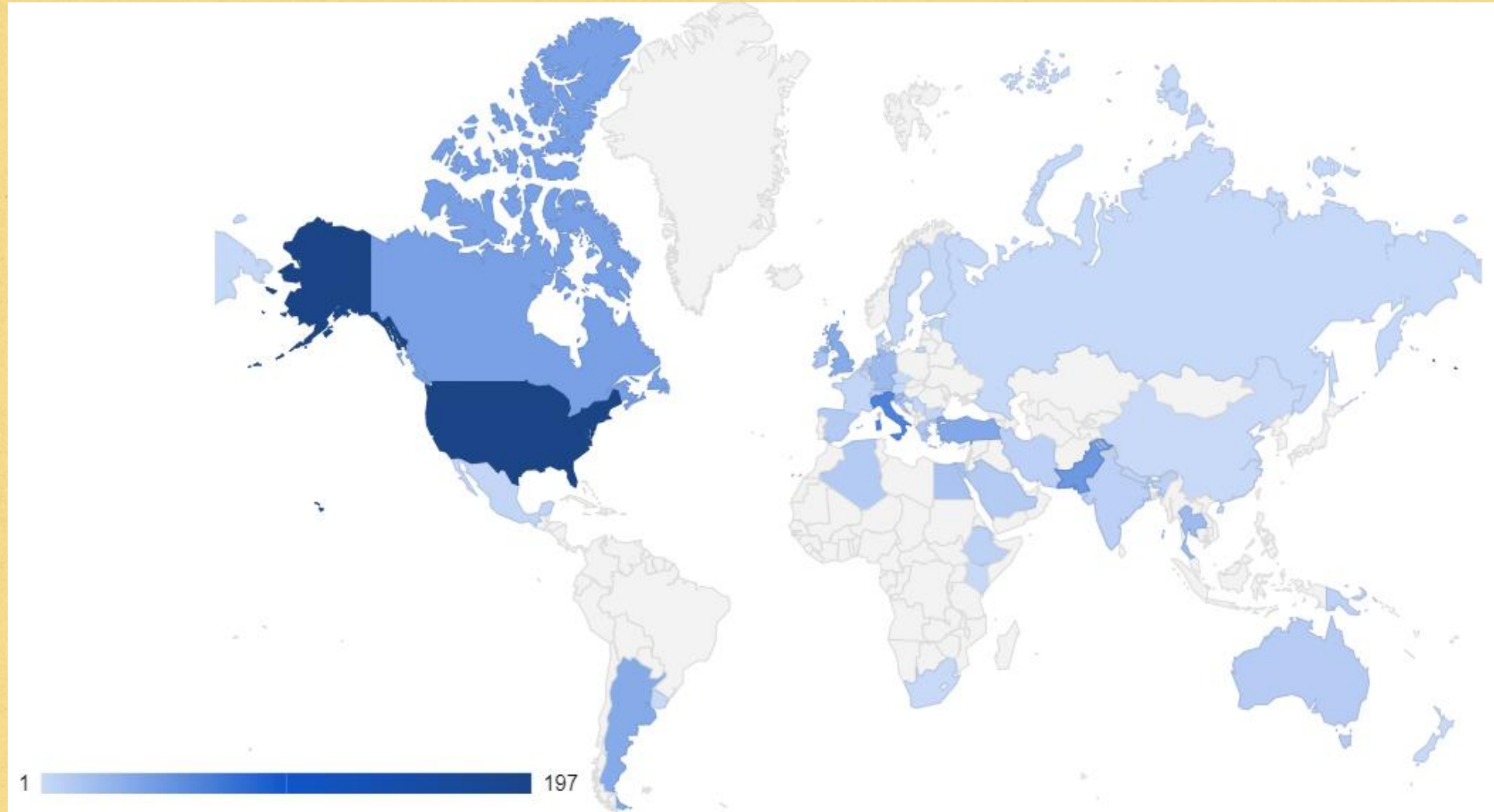
3

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	Chalkbrood	Antibiotics
	EFB	Biotechnical methods

Dataset structure: 1 line equals 1 practice record

Category	Themes	Sub-themes	Practice	Parameter	Effect	Impact	Efficacy (%)	Continent	Country	Region	Season	January	February	March
Biosecurity measures	Varroosis	"Soft" acaricides	Formic acid + oxalic acid	Varroa infestation levels	reduction	positive	89.4	Europe	Italy	Southern Europe				
Biosecurity measures	Varroosis	"Soft" acaricides	Formic acid	Adult bees mortality	increase	negative		Europe	Italy	Southern Europe				
Biosecurity measures	Varroosis	"Soft" acaricides	Formic acid	Adult bees mortality	increase	negative		Europe	Italy	Southern Europe				
Biosecurity measures	Varroosis	Biotechnical methods	Small cell foundation	Varroa infestation levels	no effect	no impact	0	North America	USA		whole year	1	1	1
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive low	37	Europe	Slovenia	Central Europe	August-September			
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive low	25	Europe	Slovenia	Central Europe	September			
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive	97	Europe	Slovenia	Central Europe	October-November			
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive low		North America	USA		spring (April)			
Biosecurity measures	Varroosis	Biotechnical methods	Swarming	Varroa infestation levels	reduction	positive low		North America	USA		summer (May - September)			
Biosecurity measures	Varroosis	Biotechnical methods	Swarming	Honey yields	reduction	negative		North America	USA		summer (May - September)			
Biosecurity measures	Varroosis	Biotechnical methods + "Soft" acaricides	Oxalic acid + swarming	Varroa infestation levels	reduction	positive moderate		North America	USA		April - September			
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive	92.7	South America	Argentina		summer (March - April)		1	
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive	94	South America	Argentina		summer	1	1	
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Varroa infestation levels	reduction	positive	92.8	South America	Argentina		autumn (May - June)			
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Residues in honey	no effect	positive		South America	Argentina		summer	1	1	1
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Residues in wax	no effect	positive		South America	Argentina		summer	1	1	1
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Residues in bees	no effect	positive		South America	Argentina		summer	1	1	1
Biosecurity measures	Varroosis	"Soft" acaricides	Oxalic acid	Adverse effects on colony	no effect	positive		South America	Argentina		summer	1	1	1
Biosecurity measures	Varroosis	"Soft" acaricides	Thymol	Varroa infestation levels	reduction	positive low	39.4	Europe	Greece	South-eastern Europe	autumn (October-November)			
Biosecurity measures	Varroosis	"Soft" acaricides	Thymol	Varroa infestation levels	reduction	positive low	40.9	Europe	Greece	South-eastern Europe	autumn (October-November)			
Biosecurity measures	Varroosis	"Soft" acaricides	Thymol	Varroa infestation levels	reduction	positive low	40,4 - 45,4	Europe	Greece	South-eastern Europe	autumn (October-November)			
Biosecurity measures	Varroosis	"Soft" acaricides	Thymol	Residues in honey	no effect	positive		Europe	Greece	South-eastern Europe	autumn (October-November)			

Results (Origin)



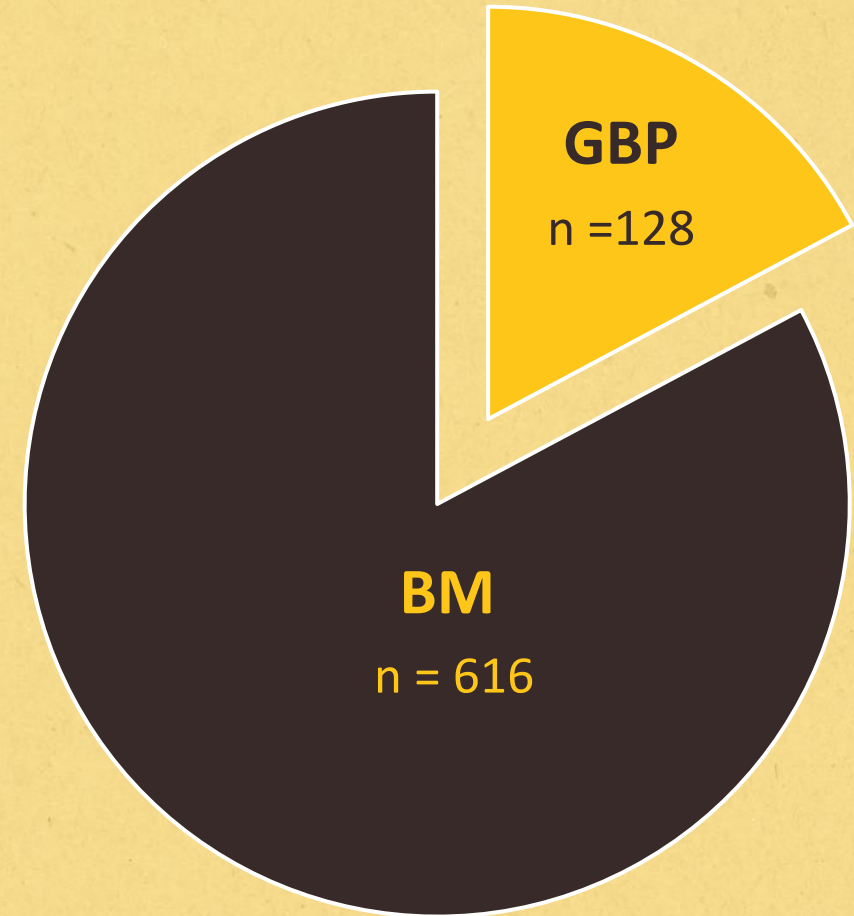
World map showing the density of identified practices.

Results (Categories)

Practice Categories

Biosecurity measures (BM)
Good beekeeping practices (GBP)

→ Two complementary pillars of colony health



Results (Themes)

Themes ranked by the percentage representation of identified practice records (n = total number of practice records).

GBP		BM							
General apiary management		Varroosis		AFB		Tropilaelapsis		Aethinosis	
n=128		n=424		n=72		n=65		n=34	
Colony management	46.9%	"Soft" acaricides	58.5%	Antibiotics	41.7%	"Soft" acaricides	81.5%	In-hive traps	55.9%
Feeding and Watering	35.2%	"Hard" acaricides	21.0%	Biotechnical methods	22.2%	"Hard" acaricides	9.2%	Hive entrance modification	17.6%
Queen management	10.9%	Biotechnical methods	9.7%	Organic agents	12.5%	Biotechnical methods	7.7%	"Soft" acaricides	8.8%
Hygiene	7.0%	Biotechnical methods + "soft" acaricides	6.6%	Laboratory testing	6.9%	Breeding for resistance	1.5%	Colony management	8.8%
		Colony management	3.3%	Colony management	4.2%			Traps outside of hives	5.9%
		Breeding for resistance	0.7%	Breeding for resistance	4.2%			Breeding for resistance	2.9%
		"Soft" acaricides + "hard" acaricides	0.2%	Stamping-out	2.8%				
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Results (Sub-themes and practice containers)

General apiary management

Colony management		Queen management		Feeding and watering	
n=60		n=14		n=45	
Starting new colonies by buying nuclei	11.7%	Annual queen replacement	42.9%	Natural forage	24.4%
Starting new colonies from splits	11.7%	Imported queens	28.6%	Agricultural forage	17.8%
Low colony densities	10.0%	Domestic queens	21.4%	Pollen supplementation	17.8%
Small hives	10.0%	Young queens	7.1%	Protein substitutes	13.3%
Swarming	8.3%			High fructose corn syrup	11.1%
Conventional operation	6.7%			Sugar syrup	11.1%
Chemical-free operation	6.7%			Supplement BEEWELL AminoPlus	4.4%
Organic operation	6.7%				
Shook swarm	6.7%				
Reusing equipment from dead colonies immediately	5.0%				
Isolated hives in winter	3.3%				
Long-distance transportation of small colonies	3.3%				
Reusing combs from pesticide-contaminated deadouts	3.3%				
Swarming + low colony densities	3.3%				
Isolated hives in summer	1.7%				
Wintering strong colonies	1.7%				

Varroosis

"Hard" acaricides		"Soft" acaricides		Biotechnical methods	
n=89		n=248		n=41	
Tau-fluvalinate	30.3%	Oxalic acid	36.3%	Drone brood removal	22.0%
Amitraz	28.1%	Formic acid	27.8%	Hyperthermia	22.0%
Coumaphos	23.6%	Thymol	22.2%	Queen caging	17.1%
Flumethrine	18.0%	Hop acids	4.0%	Powdered sugar dusting	7.3%
		VarroMed	2.8%	Requeening	7.3%
		Formic acid + oxalic acid*	1.2%	Small cell foundation	7.3%
		Lactic acid	1.2%	Swarming	4.9%
		Oregano oil	1.2%	Total brood removal	4.9%
		HiveClean**	0.8%	Trapping comb	4.9%
		Garlic oil	0.4%	Screen floor	2.4%
		Lemon grass oil	0.4%		
		Mint oil	0.4%		
		Neem oil	0.4%		
		Rosemary oil	0.4%		
		Thyme oil	0.4%		

Results (Sub-themes and practice containers)

General apiary management

Colony management		Queen management		Feeding and watering	
n=60		n=14		n=45	
Starting new colonies by buying nuclei	11.7%	Annual queen replacement	42.9%	Natural forage	24.4%
Starting new colonies from splits	11.7%	Imported queens	28.6%	Agricultural forage	17.8%
Low colony densities	10.0%	Domestic queens	21.4%	Pollen supplementation	17.8%
Small hives	10.0%	Young queens	7.1%	Protein substitutes	13.3%
Swarming	8.3%			High fructose corn syrup	11.1%
Conventional operation	6.7%			Sugar syrup	11.1%
Chemical-free operation	6.7%			Supplement BEEWELL AminoPlus	4.4%
Organic operation	6.7%				
Shook swarm	6.7%				
Reusing equipment from dead colonies immediately	5.0%				
Isolated hives in winter	3.3%				
Long-distance transportation of small colonies	3.3%				
Reusing combs from pesticide-contaminated deadouts	3.3%				
Swarming + low colony densities	3.3%				
Isolated hives in summer	1.7%				
Wintering strong colonies	1.7%				

Varroosis

"Hard" acaricides		"Soft" acaricides		Biotechnical methods	
n=89		n=248		n=41	
Tau-fluvalinate	30.3%	Oxalic acid	36.3%	Drone brood removal	22.0%
Amitraz	28.1%	Formic acid	27.8%	Hyperthermia	22.0%
Coumaphos	23.6%	Thymol	22.2%	Queen caging	17.1%
Flumethrine	18.0%	Hop acids	4.0%	Powdered sugar dusting	7.3%
		VarroMed	2.8%	Requeening	7.3%
		Formic acid + oxalic acid*	1.2%	Small cell foundation	7.3%
		Lactic acid	1.2%	Swarming	4.9%
		Oregano oil	1.2%	Total brood removal	4.9%
		HiveClean**	0.8%	Trapping comb	4.9%
		Garlic oil	0.4%	Screen floor	2.4%
		Lemon grass oil	0.4%		
		Mint oil	0.4%		
		Neem oil	0.4%		
		Rosemary oil	0.4%		
		Thyme oil	0.4%		

Results (Sub-themes and practice containers)

General apiary management

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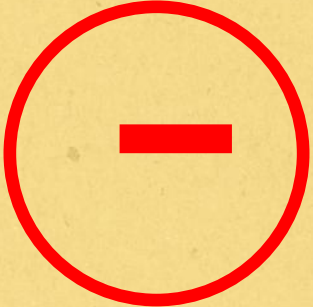
Varroosis

"Hard" acaricides		"Soft" acaricides		Biotechnical methods	
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		Lemon grass oil	0.4%		
		Mint oil	0.4%		
		Neem oil	0.4%		
		Rosemary oil	0.4%		
		Thyme oil	0.4%		

Results (Impact)

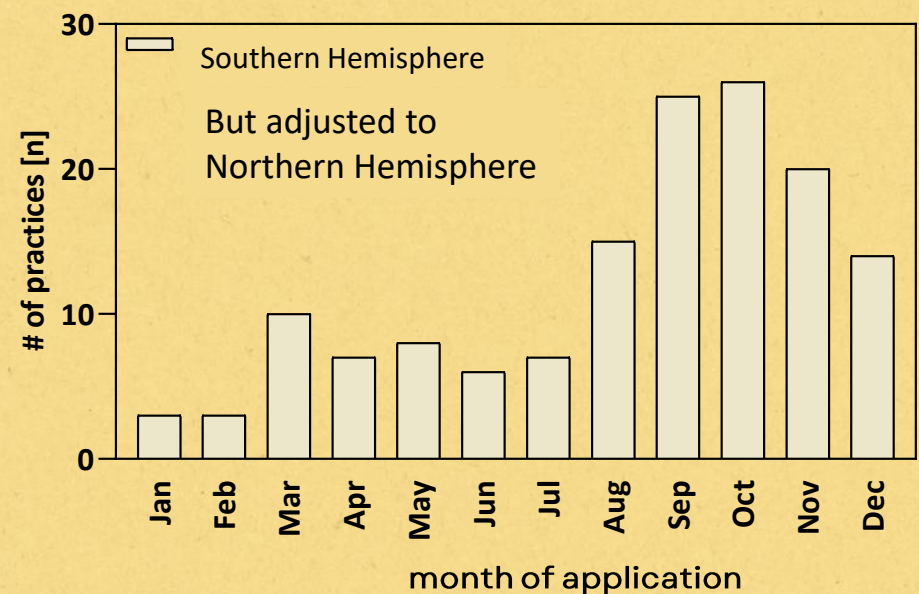
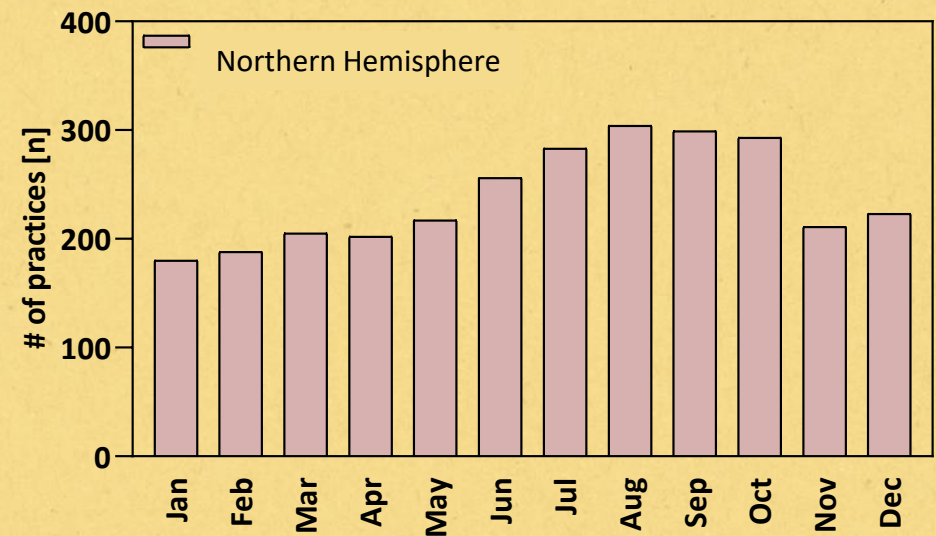
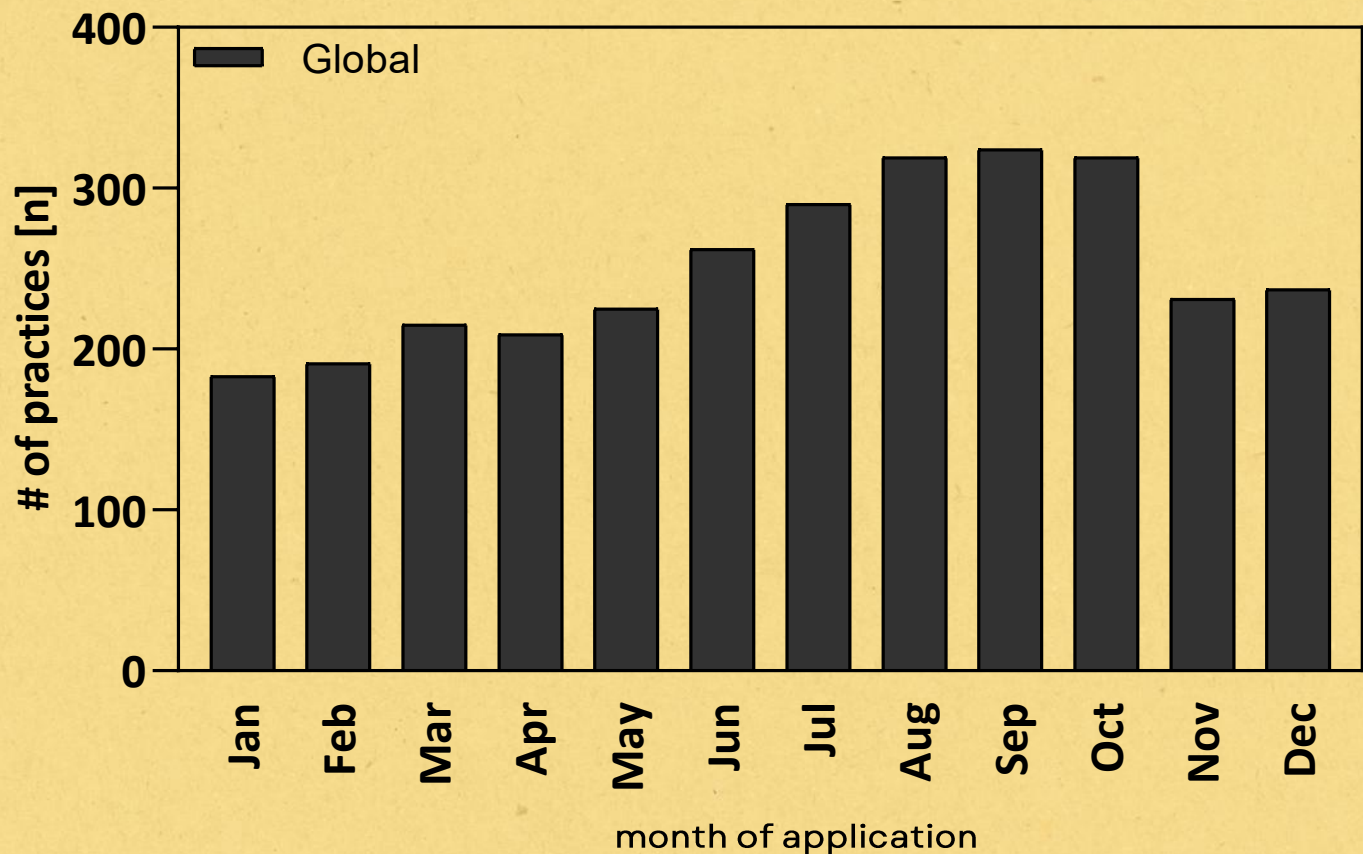
Varroa + viruses + Nosema infestation		Honey yields		Annual/winter losses + number of colonies	
n=25		n=9		n=23	
Freezing old brood comb before reuse	12.0%	Annual queen replacement	11.1%	Freezing old brood comb before reuse	13.0%
Starting new colonies by buying nuclei	12.0%	Conventional operation	11.1%	Starting new colonies by buying nuclei	13.0%
Starting new colonies from splits	12.0%	Freezing old brood comb before reuse	11.1%	Starting new colonies from splits	13.0%
Conventional operation	8.0%	Isolated hives in summer	11.1%	Domestic queens	8.7%
Low colony densities	8.0%	Low colony densities	11.1%	Reusing equipment from dead colonies immediately	8.7%
Natural forage	8.0%	Organic operation	11.1%	Annual queen replacement	4.4%
Organic operation	8.0%	Reusing equipment from dead colonies immediately	11.1%	Conventional operation	4.4%
Small hives	8.0%	Starting new colonies by buying nuclei	11.1%	Low colony densities	4.4%
Swarming	8.0%	Starting new colonies from splits	11.1%	Natural forage	4.4%
Annual queen replacement	4.0%			Organic operation	4.4%
Pollen supplementation	4.0%			Pollen supplementation	4.4%
Supplement BEEWELL AminoPlus	4.0%			Small hives	4.4%
Swarming + low colony densities	4.0%			Swarming	4.4%
				Swarming + low colony densities	4.4%
				Wintering strong colonies	4.4%

Theme: General apiary management



Colony losses		Honey yields	
n=5		n=2	
Imported queens	40.0%	Chemical-free operation	50.0%
Chemical-free operation	20.0%	Shook swarm	50.0%
Long-distance transportation of small colonies	20.0%		
Protein supplements	20.0%		

Results (Month of application)



Results (Species)

99.9% *A. mellifera*
0.1% *A. cerana*

* *A. mellifera carnica* + *ligustica*
(0.7%), *A. mellifera carnica* + *ligustica*
+ *siciliana* (0.4%), *A. mellifera carnica*
+ *yementica* (0.1%)

<i>Apis mellifera</i> ssp.	73.7%
<i>Apis mellifera ligustica</i>	12.2%
<i>Apis mellifera carnica</i>	6.3%
<i>Apis mellifera intermissa</i>	1.6%
More than 1 subspecies*	1.2%
Buckfast	1.1%
<i>Apis mellifera macedonica</i>	0.8%
<i>Apis mellifera mellifera</i>	0.8%
<i>Apis mellifera iberica</i>	0.7%
<i>Apis mellifera caucasica</i>	0.5%
<i>Apis mellifera yemenitica</i>	0.5%
africanized <i>Apis mellifera</i>	0.3%
<i>Apis mellifera scutellata</i>	0.1%
<i>Apis cerana cerana</i>	0.1%

Conclusion

- 01** A structured, expandable framework
- 02** Support in evidence-based decision-making for beekeepers, veterinarians, and extension professionals
- 03** Most research from Europe and North America
- 04** Almost exclusively on *Apis mellifera* – *A. cerana* heavily understudied
- 05** Majority on Varroosis, followed by General apiary management > AFB > Tropilaelaps > Aethinosis > EFB

Many white spots in honey bee research for the practitioner

Needs and Outlook

- 01** Expand and regularly update this framework
→ From isolated studies to holistic decision support
- 02** Identify and fill research gaps
- 03** More research targeted to field applications by beekeepers
- 04** Need to survey what information is most important to beekeepers

Thank you

CONTACT

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