Universidade Federal do Ceará
Centro de Ciências Agrárias
Departamento de Zootecnia
Laboratório de Abelhas

Abelhas como Biosensores

Antonio Diego de Melo Bezerra
Engenheiro Agrônomo
Doutor em Produção Animal

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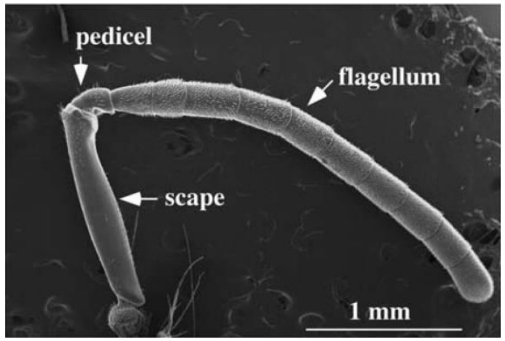
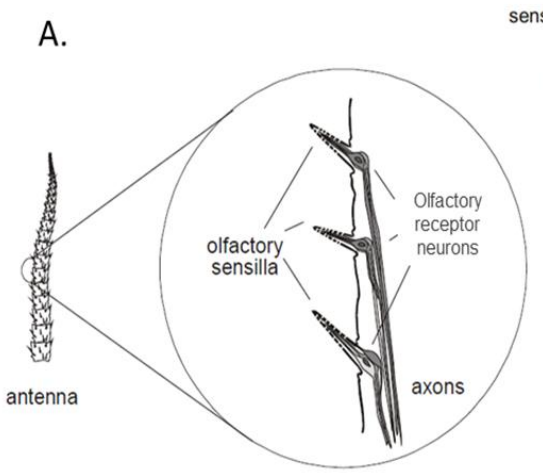
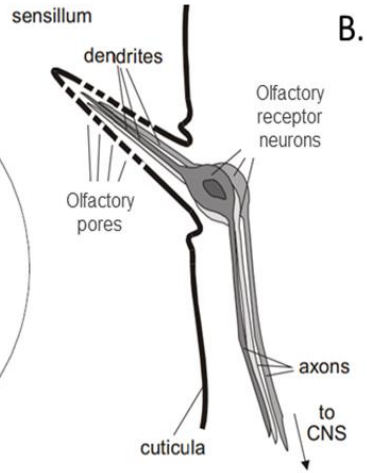
1. Introdução;
2. Referencial teórico;
3. Artigo I - Effect of the climate change on honey bee colonies in a temperate Mediterranean zone assessed through remote hive weight monitoring system in conjunction with exhaustive colonies assessment;
4. Artigo II - Continuous monitoring of beehives' sound for environmental pollution control;
5. Artigo III - Advancement of sensitive sniffer bee technology;

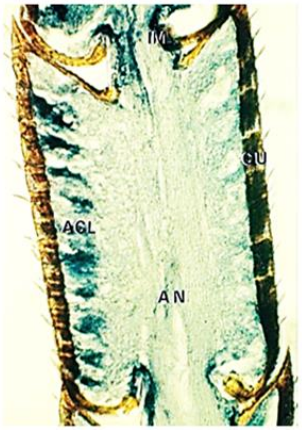
Estruturas Sensoriais:

- Ocelos;
- Olhos Compostos;
- Antenas.

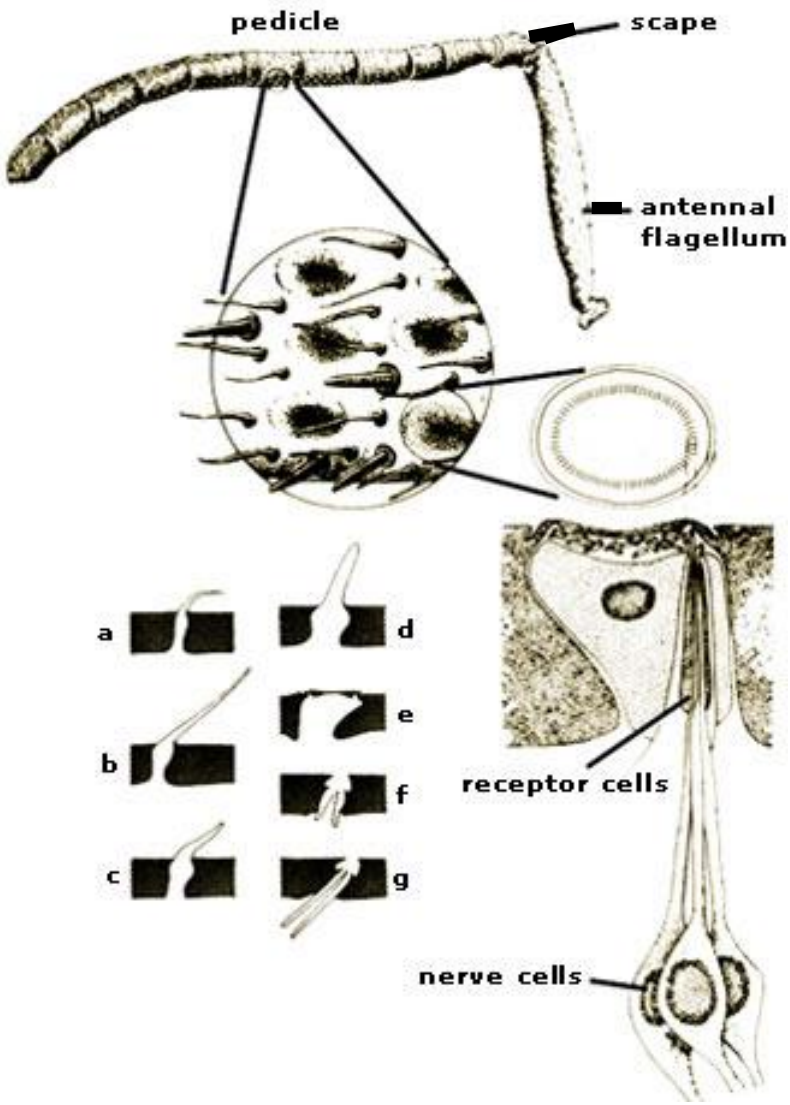








- As antenas possuem o papel na percepção de odores; von Frisch, 1967
- Alta sensibilidade olfativa o que Forel (1910) chamou de “Sentido olfativo topoquímico.”;
- As abelhas consegue identificar com precisão, direção, intensidade;
- São 7 tipos de estruturas e variam entre cavidades, placas e pêlos;
- Existem aproximadamente 3000 cavidades olfativas em uma única antena de uma abelha operária (*Apis mellifera*);
- Podem perceber concentração de gás carbônico (>1%), umidade (~5%), e temperatura.



Winston, 2003

Temperature Control in Honey Bee Colonies

Precise social cooperation permits adaptation to temperate climates

Edward E. Southwick and Gerhard Heldmaier

Termoregulação em altas temperaturas

- Aumento do número de abelhas ventilando;
- As abelhas campeiras levam água e colocam pequenas gotículas por toda a colônia e nos alvéolos que contém ovos e larvas, a perda de calor latente devido à evaporação da água (540 cal/g) favorece o resfriamento da colônia e a umidade impede a secagem das larvas;
- Uma abelha operária também pode segura uma fina película de água com sua probóscide, como acontece quando se concentra o néctar.
- Quando essas medidas de resfriamento são insuficientes, muitas abelhas deixam o ninho e se agrupam fora da entrada. Uma força suficiente de abelhas é deixada no interior para continuar as atividades de ventilação e evaporação, protegendo ovos e larvas.

Contents lists available at ScienceDirect

Science of the Total Environment

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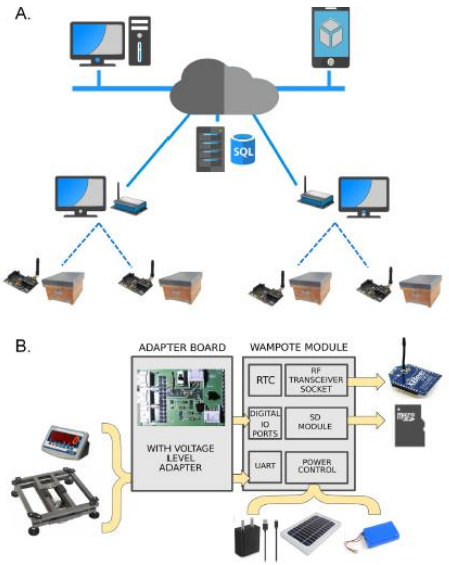
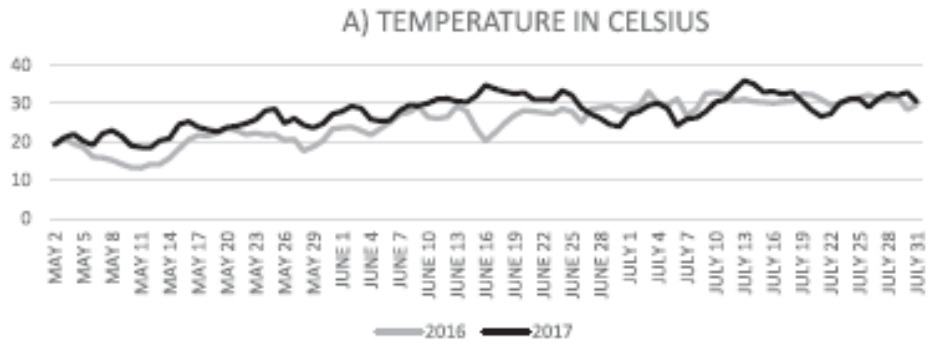
Effect of the climate change on honey bee colonies in a temperate Mediterranean zone assessed through remote hive weight monitoring system in conjunction with exhaustive colonies assessment

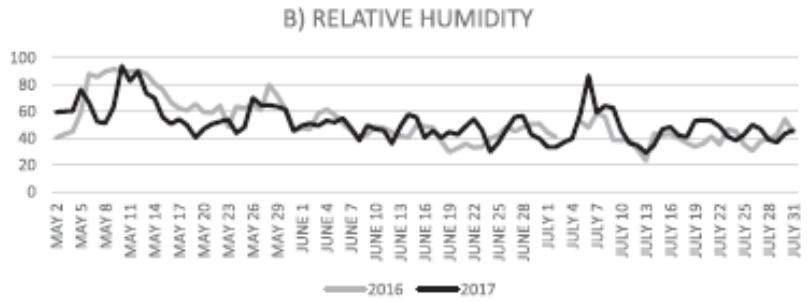
José M. Flores [a,*], Sergio Gil-Lebrero [a], Victoria Gámiz [a], María I. Rodríguez [b], Manuel A. Ortiz [c], Francisco J. Quiles [c]

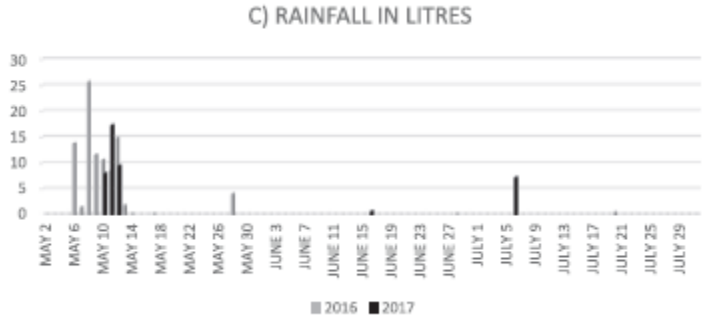
[a] Department of Zoology, University of Córdoba, Campus of Rabanales, 14071 Córdoba, Spain
[b] Department of Nutrition and Bromatology, University of Córdoba, Campus of Rabanales, 14071 Córdoba, Spain
[c] Department of Computer Architecture, Electronics and Electronic Technology, University of Córdoba, Campus of Rabanales, 14071 Córdoba, Spain

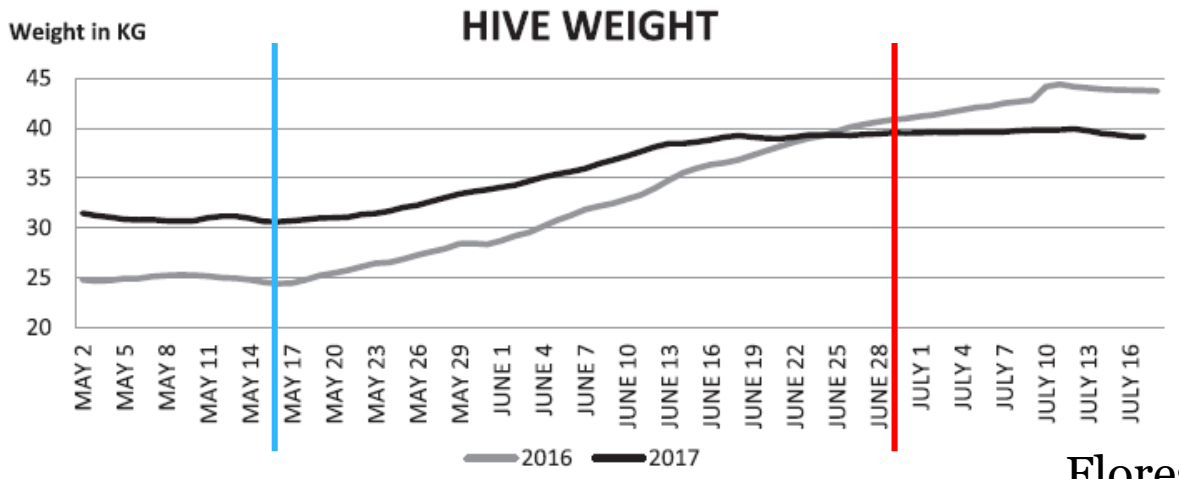


Flores et al., 2019









Flores et al., 2019

Table 2
Evolution of the variables recorded in the bee colonies in the periods between the exhaustive evaluations and throughout test period: i) Evaluation 1, in the begin of the essay in May/2nd in 2016 and 2017; ii) Evaluation 2, at the middle of each trial period in June/2nd at 2016 and June/13th at 2017 and iii) Evaluation 3, at the end of each trial period in June/18th at 2016 and June/17th at 2017. Variables were the number of adult bees, bee brood surface, surface of stored pollen (bee bread) and surface of honey stored. All surfaces are showed as cm^2. Data are reported like the mean of the bee colonies monitored of every year (six at 2016 and nine at 2017).

	Year	Parameters	Evaluation 1	Evaluation 2	Evaluation 3
Number of adult bees	2016	Mean ± s.d.	13535.7 ± 3590.7	16296.8 ± 8141.3	17216.5 ± 4137.3
		Variations between evaluations[a]	N/A	+2761.1	+919.7
		Variations throughout the test period[a]		+3680.8	
	2017	Mean ± s.d.	9575.7 ± 3570.3	14123.5 ± 6141.2	14064.1 ± 4658.7
		Variations between evaluations[a]	N/A	+ 4547.8	−59.4
		Variations throughout the test period[a]		+4488.4	
Surface of bee brood (cm^2)	2016	Mean ± s.d.	2659.3 ± 471.2	5380.3 ± 2257.5	3194.3 ± 846.6
		Variations between evaluations[a]	N/A	+2721.0	−2186.0
		Variations throughout the test period[a]		+535.0	
	2017	Mean ± s.d.	2040.9 ± 1012.2	3897.3 ± 1763.0	1579.8 ± 970.5
		Variations between evaluations[a]	N/A	+1856.6	−2317.7
		Variations throughout the test period[a]		−461.1	
Surface of pollen stored (cm^2)	2016	Mean ± s.d.	1006.8 ± 406.5	1141.0 ± 327.1	2688.8 ± 1074.6
		Variations between evaluations[a]	N/A	+134.2	+1547.8
		Variations throughout the test period[a]		+1682.0	
	2017	Mean ± s.d.	1776.6 ± 1120.4	1947.3 ± 349.2	1540.6 ± 840.1
		Variations between evaluations[a]	N/A	+170.7	−406.7
		Variations throughout the test period[a]		−236.0	
Surface of honey stored (cm^2)	2016	Mean ± s.d.	1566.0 ± 473.9	2470.0 ± 1432.3	5871.0 ± 1307.0
		Variations between evaluations[a]	N/A	+904.0	+3401.0
		Variations throughout the test period[a]		+4305.0	
	2017	Mean ± s.d.	3559.5 ± 1129.1	7434.3 ± 1598.4	6951.7 ± 1952.6
		Variations between evaluations[a]	N/A	+3875.8	−483.6
		Variations throughout the test period[a]		+3392.2	

N/A: No weight change can be computed as this is the initial stage of the study.
[a] + addresses a weight increase and – addresses a weight decrease.

Flores et al., 2019

Ecological Engineering 90 (2016) 326–330

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

Continuous monitoring of beehives' sound for environmental pollution control

Nicolás Pérez[a,*], Florencia Jesús[a], Cecilia Pérez[a], Silvina Niell[a], Alejandro Draper[b], Nicolás Obrusnik[b], Pablo Zinemanas[b], Yamandú Mendoza Spina[c], Leonidas Carrasco Letelier[c], Pablo Monzón[b]

Para avaliar mudanças críticas no comportamento da colmeia, os padrões sonoros são analisados. São apresentadas as diretrizes utilizadas para desenvolver um sistema de monitoramento remoto para detectar alterações anormais nos padrões sonoros das colmeias.

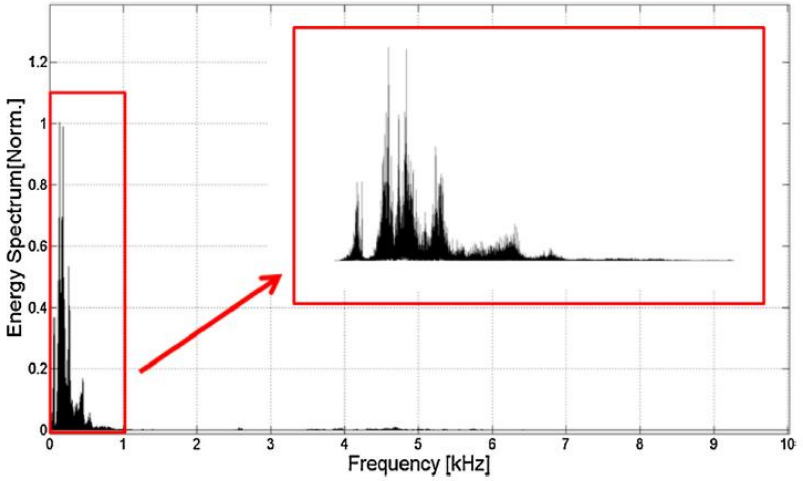


Fig. 1. Energy frequency spectrum. Note that most of the energy is concentrated in the 1 kHz band.

Pérez et al., 2016

- A evolução do espectro de freqüência amostrado em quatro janelas temporais é proposta para monitorar a saúde da colméia;
- Experimentos para determinar a banda de freqüência e a resolução de freqüência são apresentados para o caso de *Apis mellifera*;
- Usando essas diretrizes, um sistema de monitoramento completo foi desenvolvido e construído.

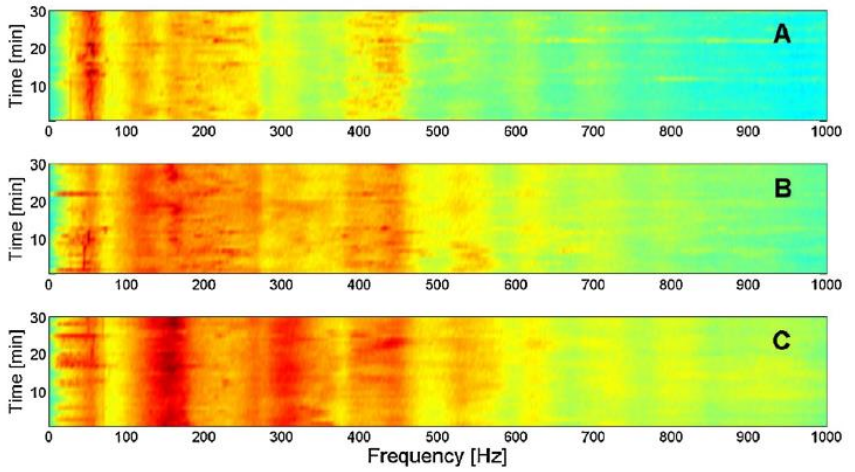


Fig. 3. Evolution of frequency spectrum at different times of the day. (A) At morning, (B) at midday, (C) at afternoon.

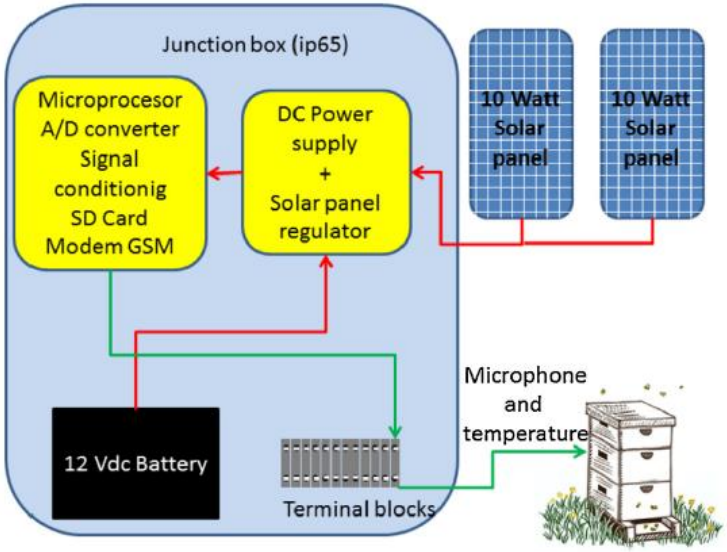


Fig. 4. Layout of the proposed system. All electronic modules are placed in IP65 Junction box for outdoor protection. The only external connections are the solar panels and the sensors' wires.

Pérez et al., 2016

- Embora vários autores proponham o uso dos padrões sonoros para monitorar as vidas, não sabemos sobre referências científicas que ligam comportamentos específicos das abelhas e padrões sonoros.

- Essa é uma tarefa de longo prazo que nosso grupo de pesquisa está começando agora. Uma etapa anterior é a coleta de dados suficientes para o reconhecimento dos padrões sadios normais de uma colmeia, para analisar ainda mais o efeito dos poluentes.

- Nessa breve comunicação, desenvolvemos uma configuração completa para a coleta de dados, observando as características relevantes da coleção, cuidando da grande quantidade de dados que podem ser gerados por um monitor contínuo e fornecendo uma comunicação bidirecional através da rede celular móvel entre as colméias. e o laboratório.

Trends in Analytical Chemistry 97 (2017) 153–158

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Trends in Analytical Chemistry

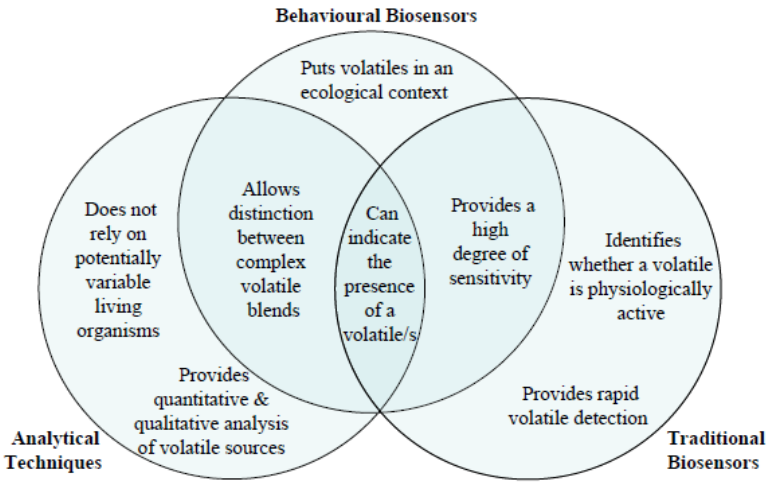
journal homepage: www.elsevier.com/locate/trac

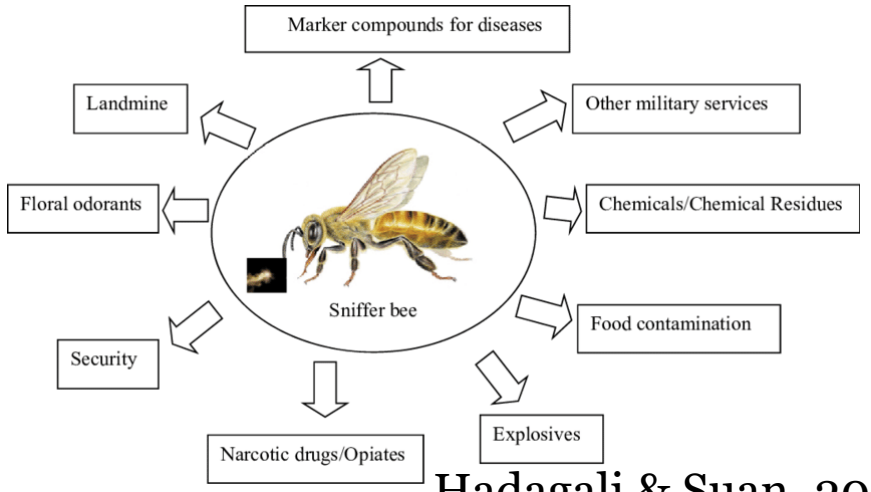
Advancement of sensitive sniffer bee technology

Manjunatha D. Hadagali [a, b, *], Chua L. Suan [b]

[a] Department of Chemistry, MS Ramaiah Institute of Technology, Bangalore, 560054, India
[b] Metabolite Profiling Laboratory, Institute of Bioproduct Development, Universiti Teknologi Malaysia, 81310, UTM, Skudai, Johor Bahru, Johor, Malaysia

O treinamento das abelhas é amplamente baseado no condicionamento de Pavlov.





Hadagali & Suan, 2017

Table 1
The application of other animals as biosensors.

Animal	Functional area	Application	Reference
Arthropod and arachnid	Defense	Detection of the presence of hidden enemies	[18]
Dogs	Defense, landmines	Detection of explosives in landmines	[19]
	Forensic	Drugs of abuse and other substances	[20]
African pouched rats	Landmines, biomedicine	Detect landmines and tuberculosis	[21–23]
Dolphins	Sea-mines	Tracing of sea-mines	[24]
Rats	Defense, landmines	Offering an alert when explosives are present using a remote monitoring technique	[25]
Honeybee	Biomedicine;	Detection of *Mycobacterium tuberculosis;*	[26]
	Detection of food adulteration;	The assessment of quality of honey samples;	[76]
	Identification of narcotics;	Detection of concealed cocaine, heroin;	[27]
	Explosives and landmines	Identification of 2,4-dinitrotoluene and volatile compounds from landmines	[42–45]

Table 2
The application of honeybee as chemo-biosensor in various fields.

Functional area	Application	Reference
Identification	Simultaneous identification of natural odors	[3]
Identification	Flowering plants	[1]
Identification and differentiation of carbon compounds	Discriminate between hundreds of odorants with exquisite sensitivity and specificity based on the odorants' carbon chain length, as well as type, position and number of functional groups	[8,41]
Identification	Identification of components of the odor from oilseed rape flowers	[27]
Identification of explosive	Identification of 2,4-dinitrotoluene	[42–44]
Identification of Landmine	Volatile compounds from landmines	[45,46]
Study of olfactory perception and olfactory learning in workers and drones	This technique provides a valuable tool for investigating odor perception in honeybees, especially questions relating to the discrimination of similar odors including the same odor at different concentrations	[4,10,57,58]
Behavioral study on learning of complex odors by honeybees by PER paradigm	Identification of 32 different odors	[79]
Landmine, Security and Biomedicine	Identification of landmine chemicals and other explosive materials, drugs and even decomposing bodies at very low concentrations	[44,71]
Identification of narcotics	Detection of concealed cocaine, heroin and 3,4-methylenedioxy-N-methylamphetamine in small amounts	[27]
Sniffing of nicotine, explosives, and biomedicine	Sniff out cigarettes to recognize low levels of nicotine; to detect explosives, drugs and other illegal substances in cargo containers	[74,75]
Detection of food adulteration	The assessment of quality of honey samples of different origin	[76]
Biomedicine	Detection of *Mycobacterium tuberculosis*	[26]

Hadagali & Suan, 2017

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