Pheromone Basics

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In cooperation with Animal Biotech (www.animal-biotech.com)

Terminology

- Semiochemical – a generic term for chemical signal(s) that carry a message (could be within or between species). Semiochemicals include pheromones, allomones, kairomones, interomones, attractants, repellants, individual odor signatures, gender signatures and more.
- Pheromone – A species-specific chemical that triggers a behavioral and/or physiological response. Sex, alarm, food finding, maternal-neonatal and others.
- Interomone -- An interomone is defined as a semiochemical that acts as pheromone of one species but elicits physiological responses in a different species where the pheromone molecules have not yet been identified

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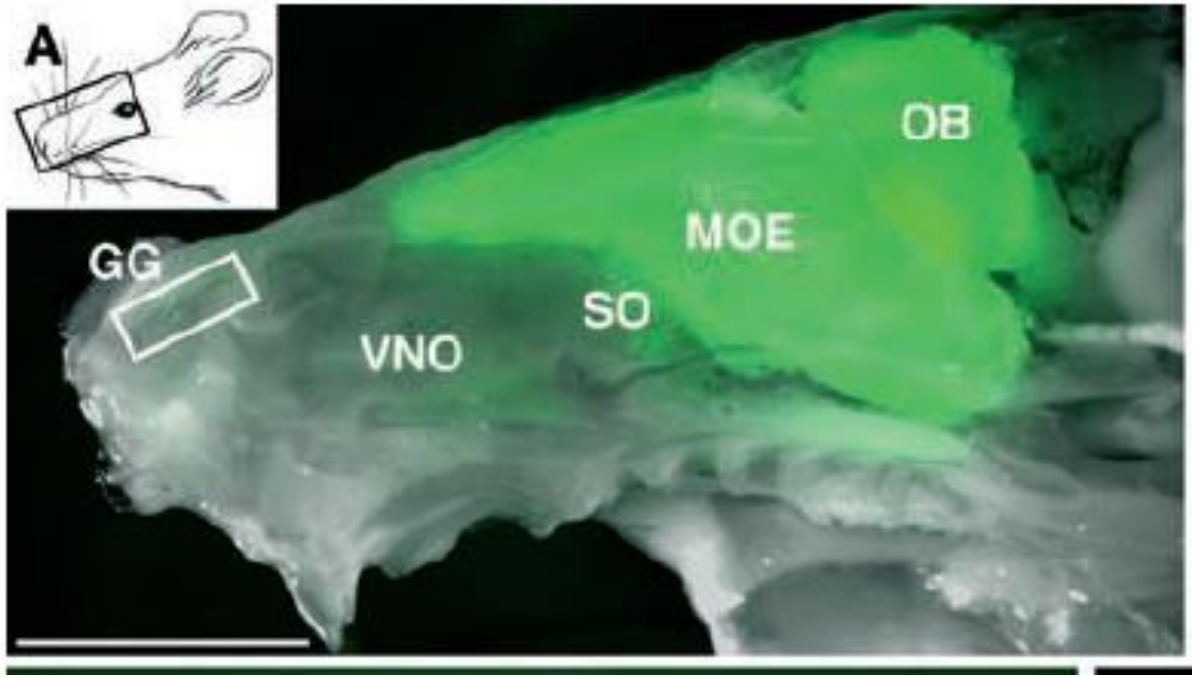
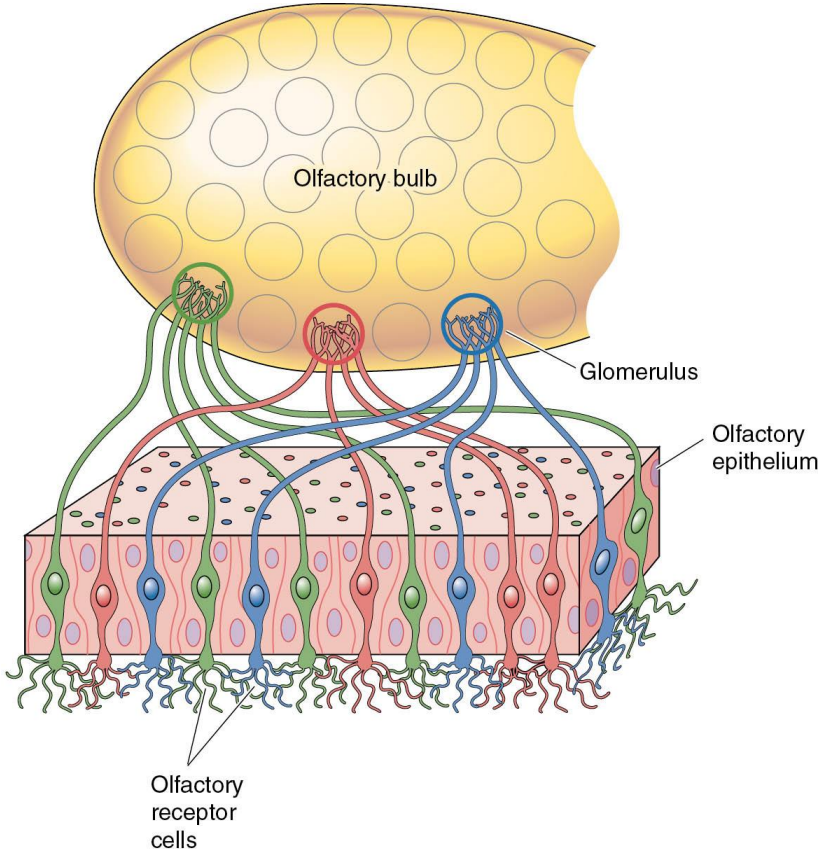
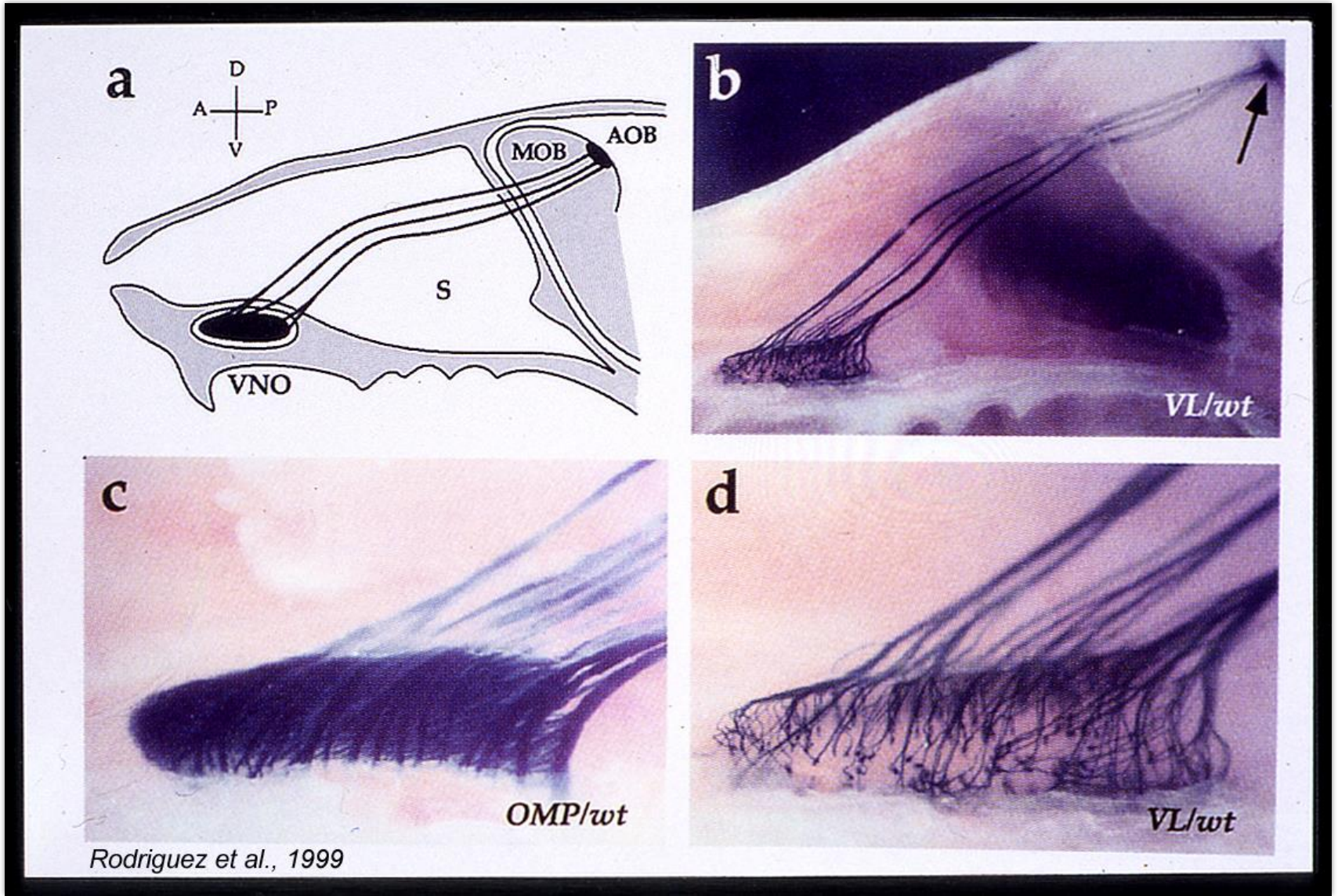
Grueneberg Ganglion, Septal Organ, Vomeronasal Organ, Main Olfactory Epithelium, Olfactory Bulb



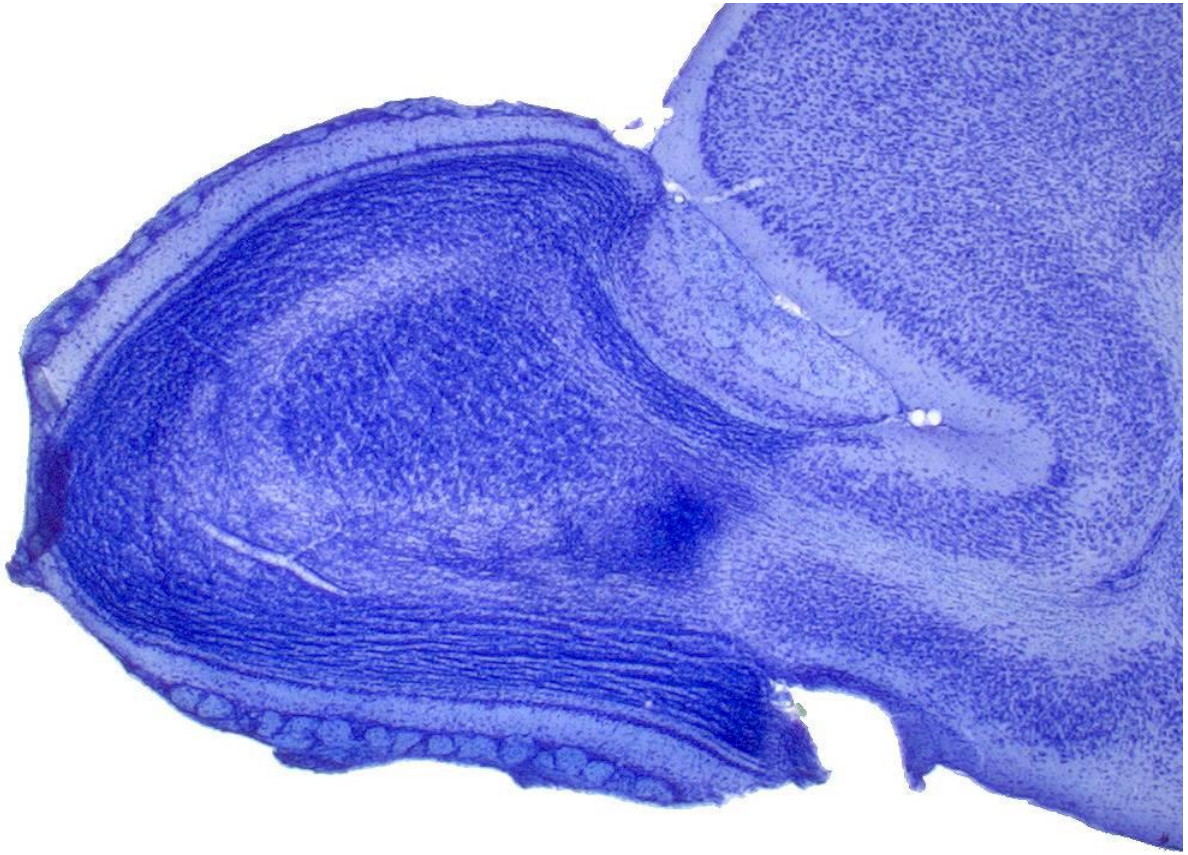


Brechbuhl et al., 2009. Science.

VNO connection to the AOB

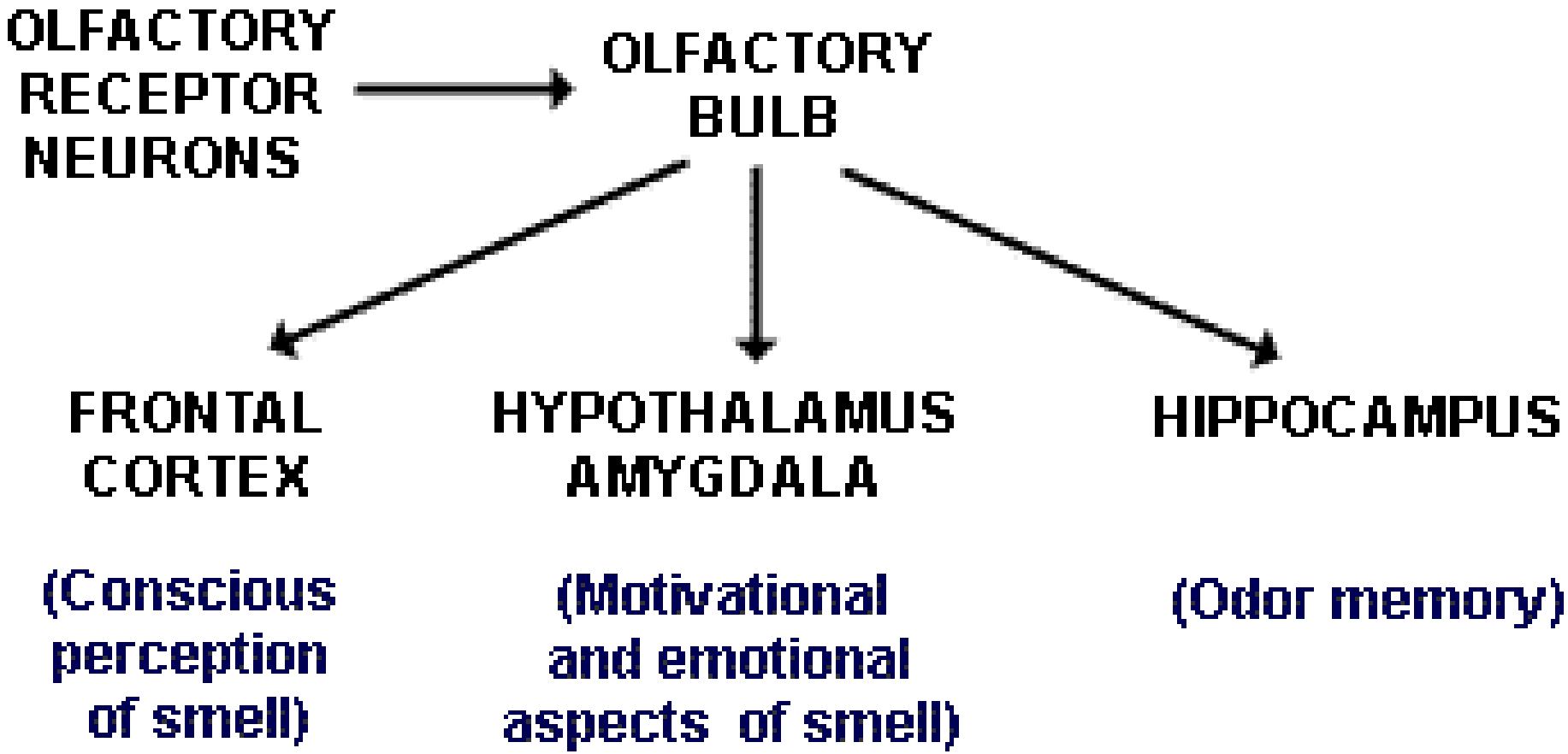


Pig Olfactory Bulb and AOB



Salazar, 2000

Olfactory brain pathways



https://faculty.washington.edu/chudler/chems.html

Conservation of Semiochemicals

- Chemical signals are conserved from insects through mammals.
- A given molecule(s) can be a pheromone (or interomone) in two species as long as they operate in different geographies or times, for example:
  - Bark beetle aggregation pheromone = elephant sex pheromone (Frontalin)
  - Pig sex pheromone ---- stops dogs from barking

Olfactory Receptors

Species	Functional OR genes	% Functional genes	Number Pseudogenes
Human	388	48%	414
Pig	**1,113**	**86%**	**188**
Cattle	881	82%	190
Mouse	1,037	75%	354
Chicken	82	15%	476

Lee et al., 2013. BMC Genomics.

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Historical views

Old thinking

- One pheromone molecule
- Pheromones work through the VNO
- Numbers of OR determine olfactory acuity

New thinking

- One or multiple pheromone molecules
- Several sensory systems bind pheromones
- Olfactory binding proteins, ORs, and brain integration provide more complex signaling

What we know about sex pheromones

Male Sex Pheromone in Goats

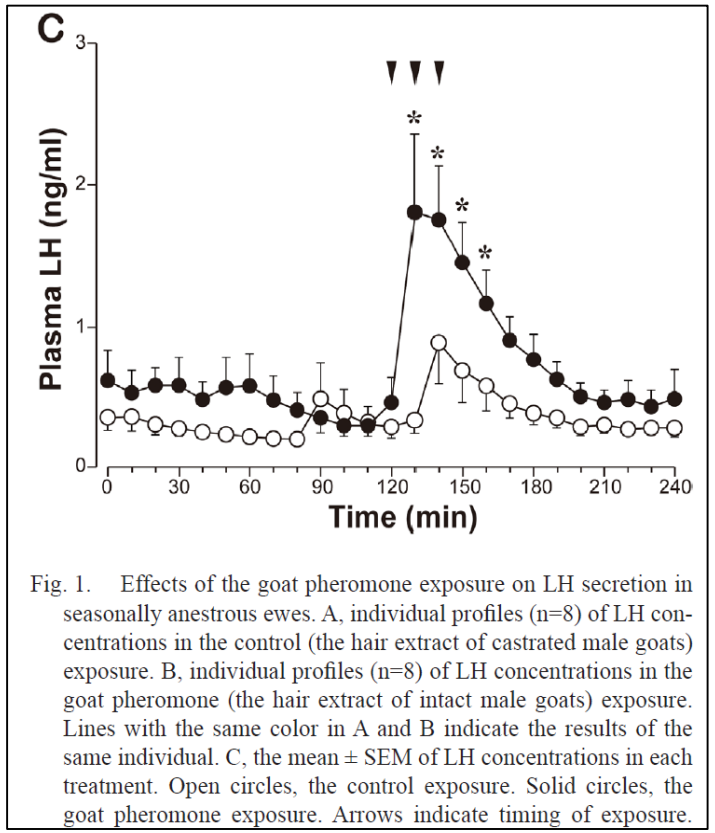
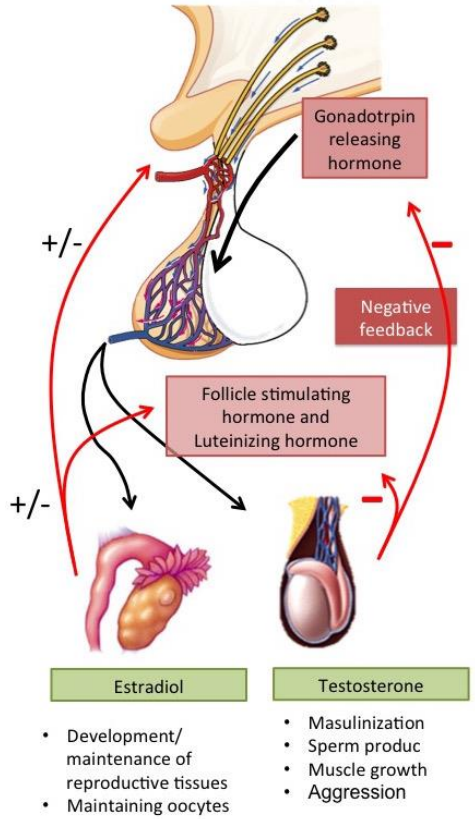


Fig. 1. Effects of the goat pheromone exposure on LH secretion in seasonally anestrous ewes. A, individual profiles (n=8) of LH concentrations in the control (the hair extract of castrated male goats) exposure. B, individual profiles (n=8) of LH concentrations in the goat pheromone (the hair extract of intact male goats) exposure. Lines with the same color in A and B indicate the results of the same individual. C, the mean ± SEM of LH concentrations in each treatment. Open circles, the control exposure. Solid circles, the goat pheromone exposure. Arrows indicate timing of exposure.

O'Hara et a., 2014 doi: 10.1292/jvms.14-0260; *J. Vet. Med. Sci.* 76(10): 1329–1337, 2014

4-ethyloctanal

GnRH → LH → Lordosis & Ovulation



WHY DOESN'T ANDROSTENONE (alone) WORK?

Source	Odor source	Sows showing estrus
Hafez, 1962/Signoret, 1961	Nothing	59%
	Boar odor in pen	81%
	Fence-line boar contact	97%
Melrose, 1971	Androstenone	78%*

* Androstenone alone does not cause the same effect as a boar

Background thinking

- Androstenone is/was not enough to replace the boar
- Many newly-discovered pheromones are mixtures of molecules (rather than a single molecule) – ex., alarm pheromones
- We knew from the 1970's that androstenol and androstenone gave about the same response in eliciting lordosis behavior
- Did the early scientists not find all of the pheromone molecules?

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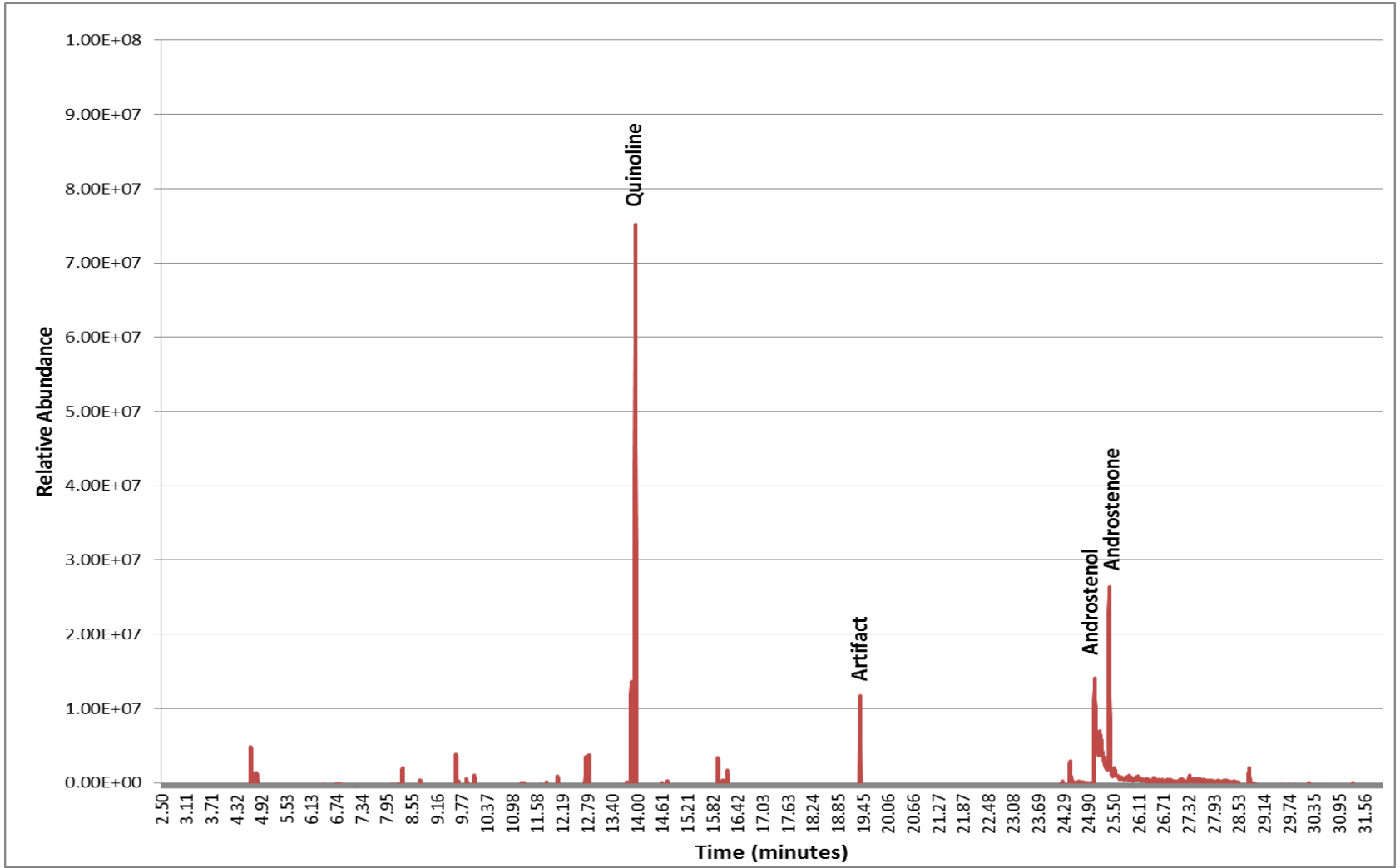
SPME-GC-MS Analysis of boar vs sow saliva

Three boar-specific salivary molecules:

- Androstenone
- Androstenol
- Quinoline



Boar Saliva samples from a commercial farm

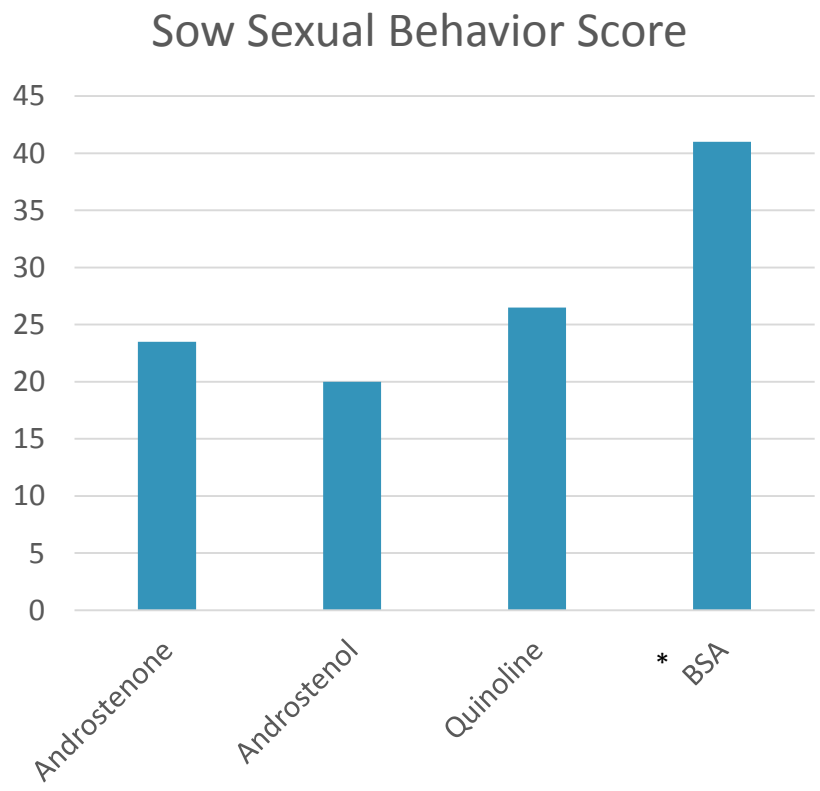
Boar	Quinoline, ppm	Androstenol, ppm	Androstenone, ppm
1	4	33	18
2	4	16	6
3	4	15	4

Next steps

Steps

- Find out if one molecule or a mixture is more potent
- Tested each molecule alone or in combination (8 evaluations)
- Commercial farm with 947 sows observed
- Determined that the combination of all 3 molecules had a synergistic effect on sow sexual behavior compared with each molecule alone.
- Boar Saliva Analog (BSA) developed

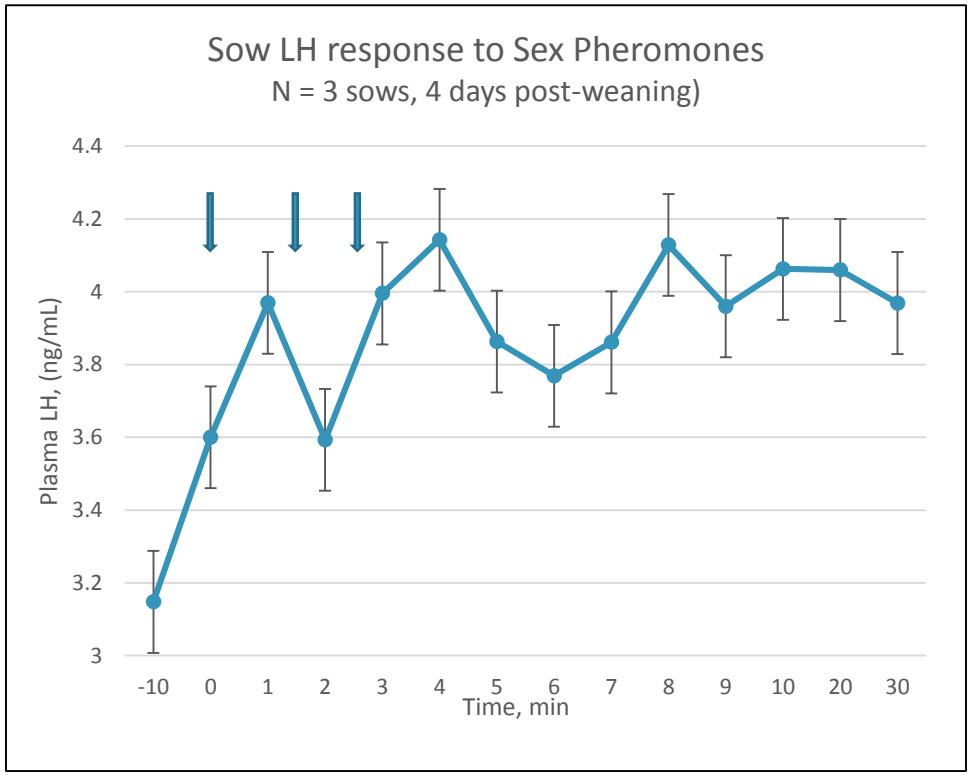
947-sows on a commercial farm



BSA stimulates sow LH secretion

Two studies

- First study, bled each sow by catheter each 10 min before and after BSA spray.
- Second study, bled each sow by catheter each 1 min after BSA spray
- BSA caused a pulse of LH that lasted more than 10 minutes in sows 4 days after weaning



Arrows indicate BSA administration

Conclusions

- The boar produces three unique molecules in his saliva that sows do not produce
- When formulated either in alcohol or a water-based emulsion, BSA:
  - Causes an immediate sexual behavioral response in weaned sows
  - Causes a surge in LH, much like giving GnRH
- We can use pheromones to improve performance and change behavior in adult and growing pigs

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Conclusions

- Pheromones are ***not*** hormones and they are ***not*** drugs
  - No regulatory requirement
  - Synthetic analogs of natural molecules
- A deficiency of pheromones limits biological potential
- Pheromones have been called clean, green and ethical technology

Journal of Reproduction and Development, Vol. 52, No. 1, 2006

"Clean, Green and Ethical" Animal Production. Case Study: Reproductive Efficiency in Small Ruminants

Graeme B. MARTIN[1] and Hiroya KADOKAWA[2]

Patents

Pheromone composition to stimulate reproduction in female suids and methods of use

US 9480689 B1

ABSTRACT

The present disclosure provides for compositions and methods of stimulating reproductive behavior and reproductive success and productivity in a suid, such as pigs. The composition may comprise at least one steroid hormone and a heterocyclic aromatic compound. The method comprises administering the pheromone composition to the suid for a period of time.