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MEDICINE

Evidence Based Behavioral Management

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Goals and Objectives

- **Goal: To show how information many facilities already gather can be analyzed in ways to make better decisions**

- Example 1) Socialization data guiding priorities
- Example 2) Finding easier measures for tracking abnormal behaviors
- Example 3) Tracking behavior to explore its etiology

NIH Socialization Data

- Dedicated behavior database maintained 2000-2010
  - Behavior observations
  - Environmental Enrichments
  - Basic socialization Data
  - Maintained as part of basic record-keeping, not expressly for analysis
- Dearth of socialization “how to” publications
  - Mostly anecdote and word-of-mouth on which socializations are easiest, longest lasting
  - At NIH, hadn’t really analyzed why our socialization metrics seemed to have a ceiling
  - Had applied same process to all socializations for sake of uniformity
  - Possibly apocryphal “knowledge” persisted that animals who had been singly housed for longer were more difficult to socialize

NIH Socializations 11/00-12/04

- 1572 “first” socializations
  - 499 F, 1070 M (others “unknown”)
  - 8 Different primate species
- Mixed logistic regression
  - Dependent variable: success
  - Independent: sex, age, species, latency between arrival and pairing, “group” size

NIH Socialization Results

- Females 0.33 times more likely to be successful than males ($p=0.001$)
- Age inversely correlated with success ($p=0.004$)
- # Socialized directly correlated with success ($p<0.001$)
- Cynos and Pigtails trend toward being harder to pair than rhesus ($p=0.08$ and 0.06 respectively)
- Latency to pairing is not related to success ($p=0.57$)

So What?

- How long the animal has been in the facility is unimportant compared to their age
- Rhesus are likely the easiest macaques
- Females are easier than males
- Groups are easier than pairs
- Further analysis –
  - Adult pairs “persist” longest
  - Adult singletons contribute most to “ceiling” of socialization metrics

Title: Evidence Based Behavioral Management

Problem and analysis method: Which socializations are easiest? Which drive our metrics?

Summary: Animal demographics and group size predict success more than the process of socialization we follow. Adult socializations determine the ceiling of relevant metrics

Impact of the analytics study

Decisions made/Actions Taken: **Focus less effort on groups and juvenile pairs, more effort on adult pairs**

Calculated or actual Improvements:

Animal Welfare ***More animals socialized***

Resource use ***fewer man hours used to observe pairs or groups that are almost assured success, reclaiming these hours to focus on pairs that are more difficult but more impactful***

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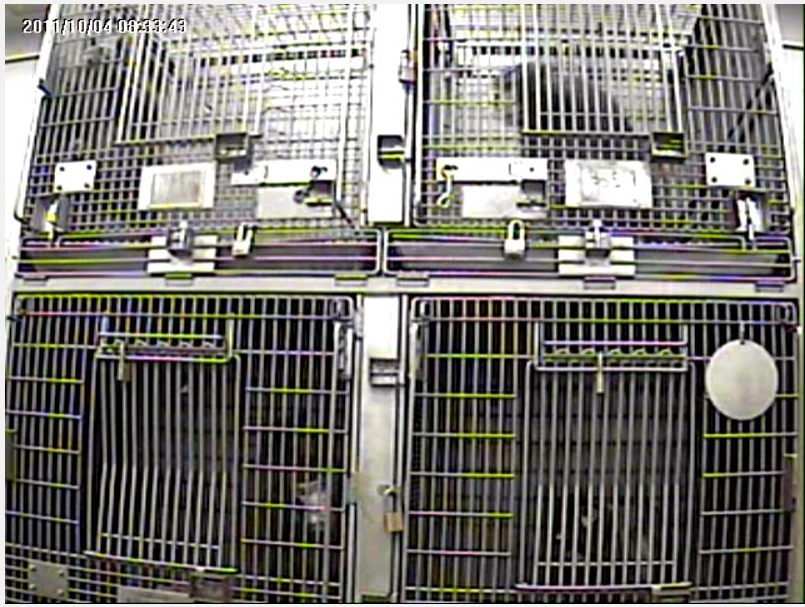
A Better Way to Measure SIB

- Self-injurious behavior is a severe form of abnormal behavior seen periodically in captive macaques
- Several barriers to studying SIB as a phenomenon
  - Assembling a cohort
  - Analysis accounting for cyclical nature of the disease
  - Measuring the behavior or its effects

How to Measure

- Behavioral observation
  - Most Common
  - Problems:
    - High manpower costs
    - Sporadic, infrequent
    - How much observation is needed for representative sampling?



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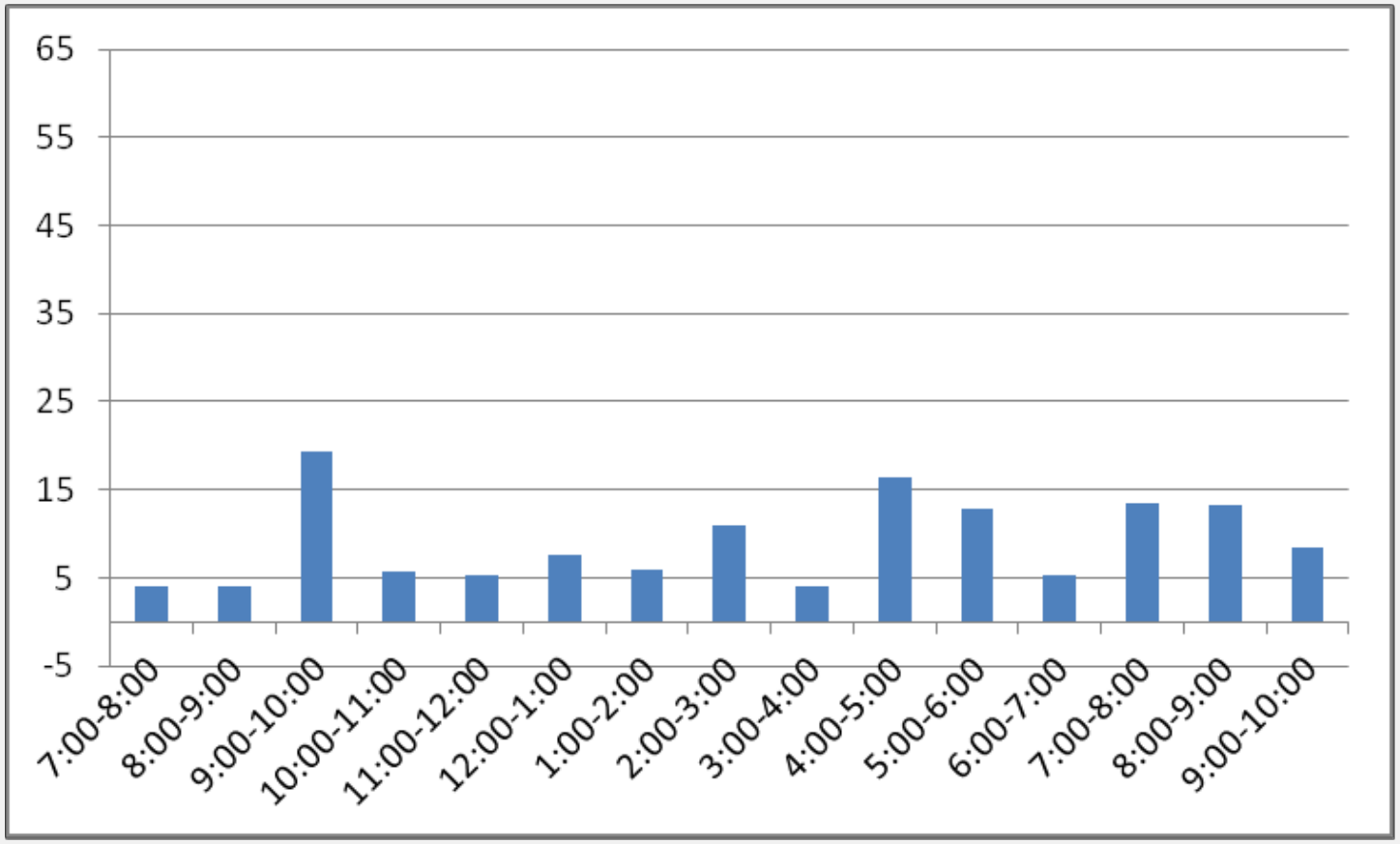
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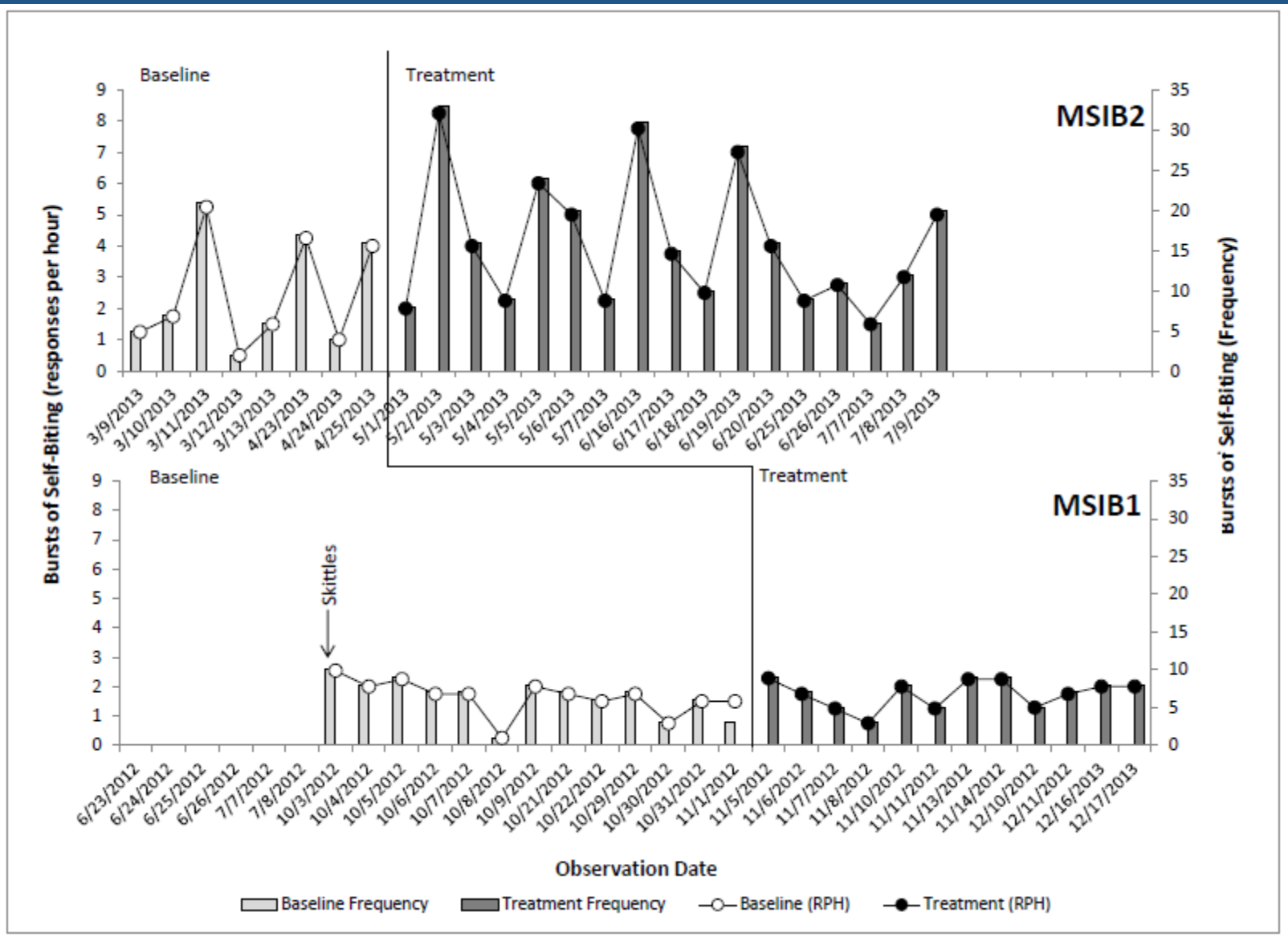

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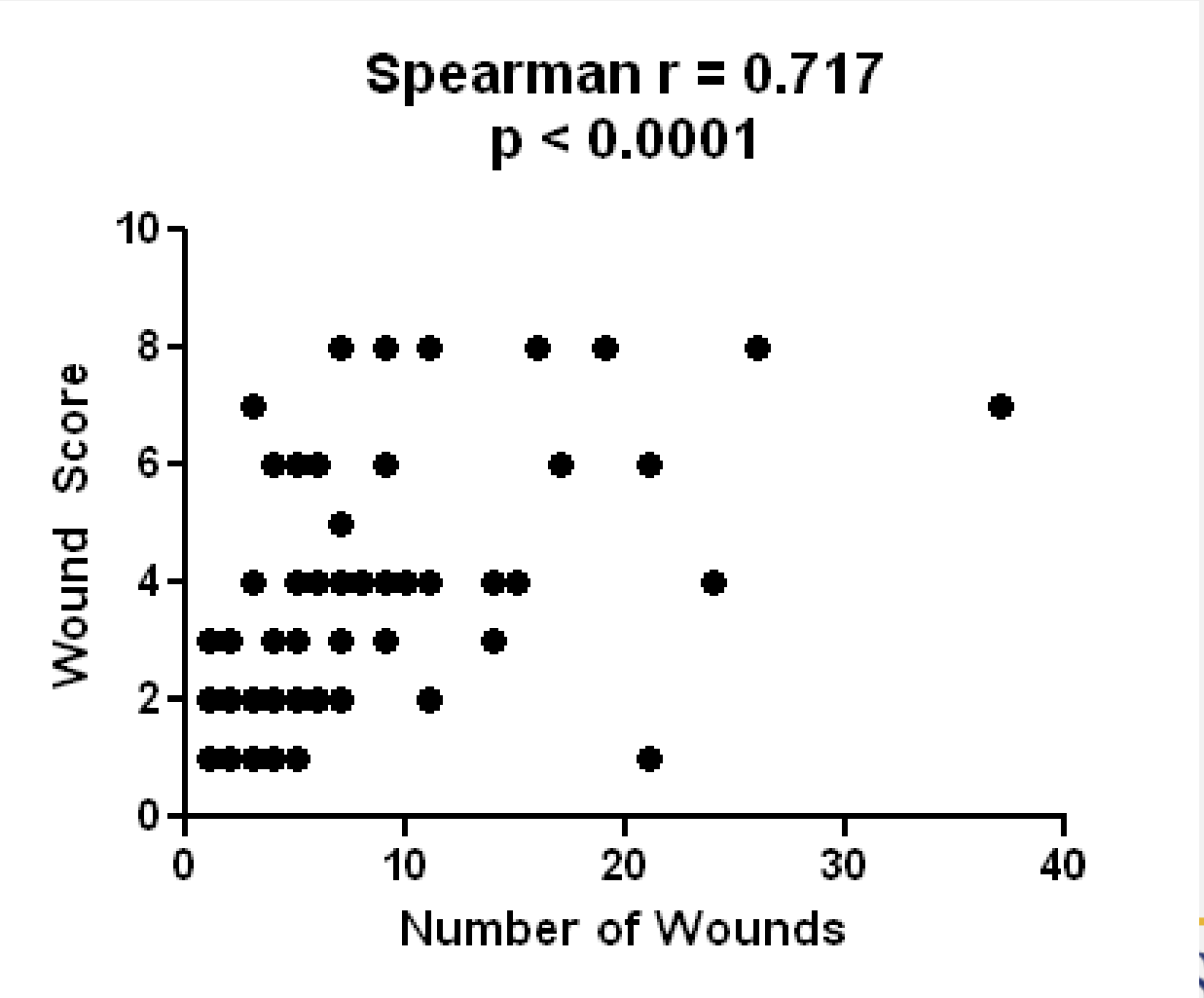
JHU Wound Scoring System

- An attempt to objectively assess wounds according to their clinical relevance
- Synthesis of wound severity and *distribution*
  - Based on clinical observation that animals wounding more than one limb display “worse” SIB
  - Wounds categorized on a 4 point scale
  - Each limb receives a score representing the highest severity wound on that limb
  - All four limb scores are added (max score 16)
- Quick and repeatable
- Reliable between observers (>95%)
- Stable over time within individuals (matching $p < 0.001$)

Wound Score vs. Number of Wounds



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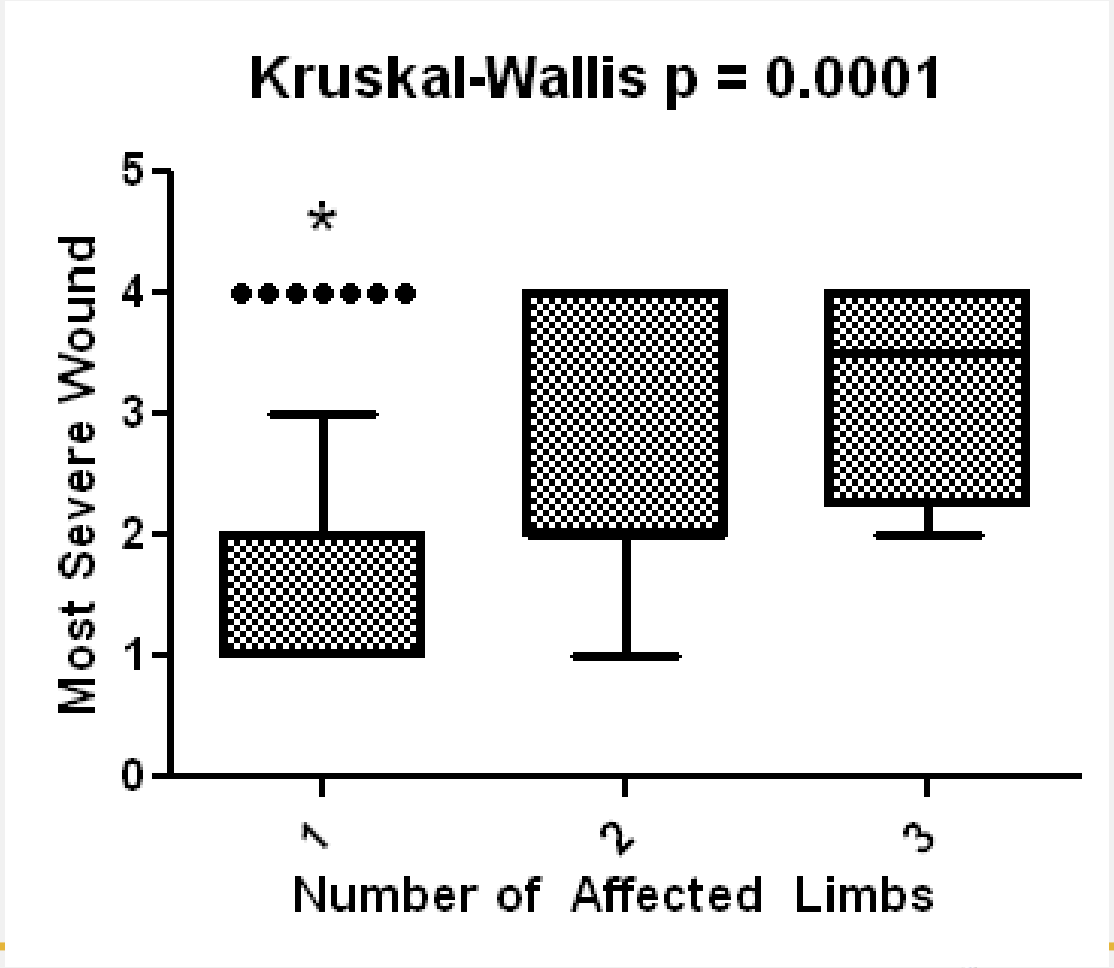
Distribution and Severity



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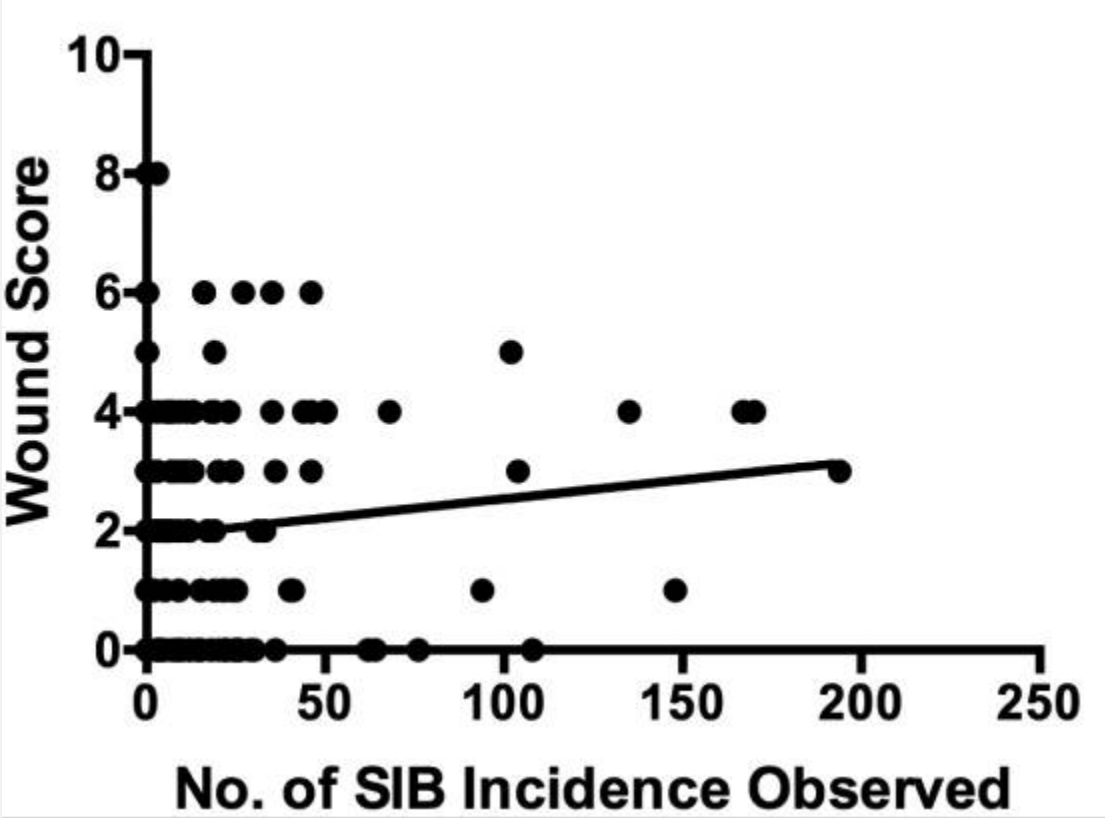
Wound Score vs Observed Behavior



Wound score correlates with the incidence of observed SIB (P = 0.008; z score, 2.63)

Title: Evidence Based Behavioral Management

Problem and analysis method: How to measure SIB? Can it be done quickly and reliably?

Summary: Wound scoring correlates with the gold standard of video observation, is faster, and is reliable among raters.

Impact of the analytics study

Decisions made/Actions Taken: **Measure SIB routinely via cage-side wound scoring rather than expensive and time consuming video observation**

Calculated or actual Improvements:

Animal Welfare ***Tracking SIB more reliably and more frequently allows for much tighter titration of treatments***

Resource use ***Exchange a <5 minute wound score observation for a video observation that takes at least 1 hour to be effective***

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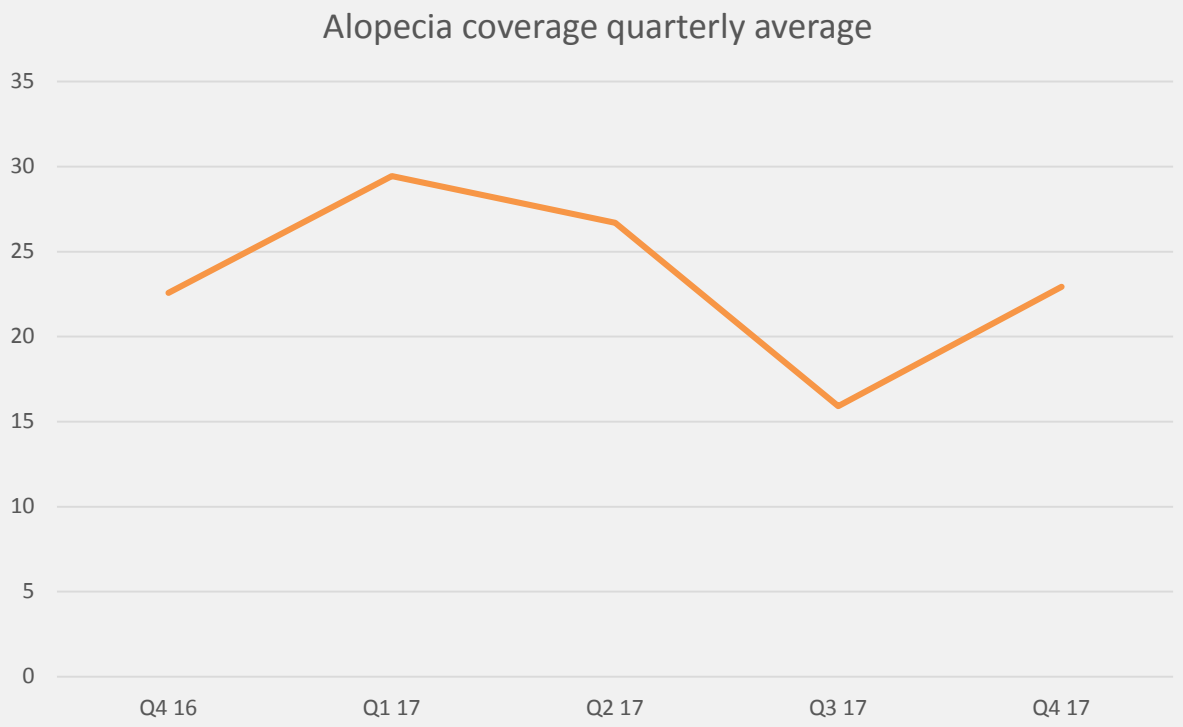
Alopecia in Group Housed Macaques

- Alopecia (hair loss) is considered a potential indicator of distress in NHPs
  - Emphasized by regulatory bodies to varying degrees
  - Rhesus undergo seasonal cycles of hair growth and loss in the wild
  - How much do seasonal changes contribute to observed hair loss in indoor/outdoor, group housed macaques?

Alopecia Data

- Starting Q4 2016, measure alopecia according to Bellanca et al. 2014
  - Simple, reliable system based of the "rule of 9s"
- Measured by trained personnel on a quarterly basis

Alopecia Coverage



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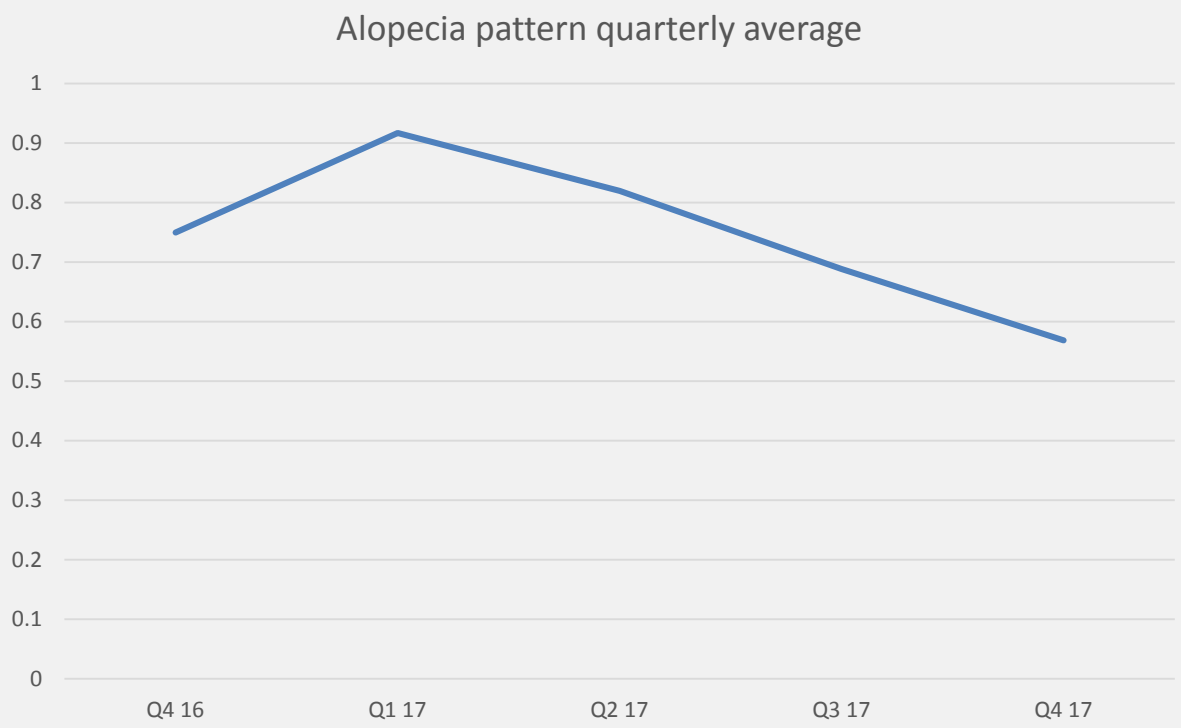
Alopecia Pattern



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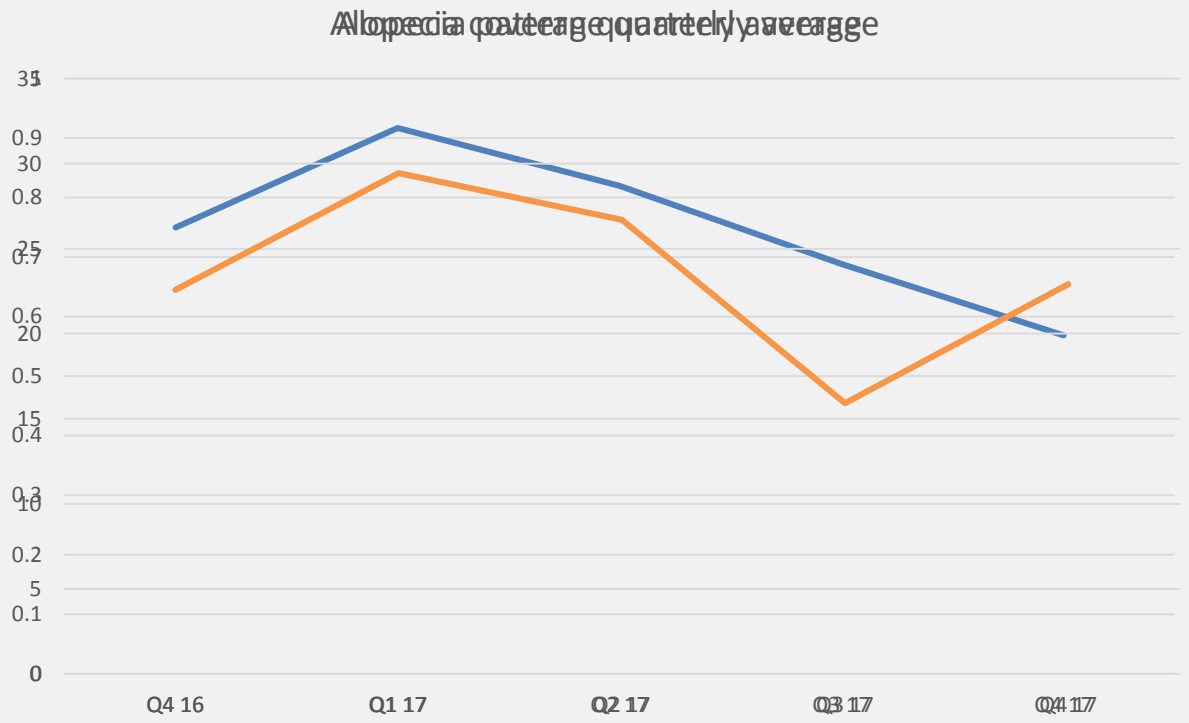
Alopecia Pattern



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Title: Evidence Based Behavioral Management

Problem and analysis method: From basic alopecia data, can we determine contribution of seasonal molt?

Summary: Seasonal trends are emerging from ongoing data collection, and will be further analyzed against other variables as this continues

Impact of the analytics study

Decisions made/Actions Taken: **May be able to stop seasonal fluctuations in behavior staff effort/resources and instead maintain focus on animals whose group contributes more to alopecia than the season**

Calculated or actual Improvements:

Animal Welfare ***Refocusing on alopecia where it is possibly reflective of behavioral pathology rather than basic physiology***

Resource use ***Focus less on trying to treat a whole colony due to seasonal fluctuation, instead focusing on animals where the group explains more of their alopecia***

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Comparison of Sire Conception Rates in Rhesus Macaque (Macaca mulatta) Males Between Two Harem Breeding Arrangements

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Johns Hopkins University Rhesus Macaque Breeding Facility

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- Formed in the 1990s
  - Supply JHU with SPF Indian-origin rhesus
- Approximately 280 rhesus
- Supply both JHU and other institutions

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- Breed in harems
- Breeding season
  - Mid-late September to early February
- Birthing season
  - Early March to August.
- Females remain in natal groups
- Males weaned at approximately12- 16 months
- Breeding males are moved to new harems when the oldest daughter is 3.

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- 19 Harem Groups
  - 5- 33 Individuals
    - 1 breeding male
    - 3 – 19 sexually mature females
    - Sub-adult/juvenile females, and infant males/females
- 16 Breeding Males

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- Prior to 2013
  - Shortage of breeding males
    - Harems were combined
      - Fighting/ Injury
      - Separation of groups
        - Resulted in formation of new groups
    - Harems went without breeding males
      - Reduced the colony's potential birth rate
      - Per diems spent on females that weren't bred

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- Solution to male shortage:
  - Alternate males between two harems
    - Alternate every 6 weeks
    - Continue after breeding season
      - Maintain rank/ relationships within groups
  - Determine if sire conception rate (SCR) was affected

Johns Hopkins University SPF Rhesus Macaque Breeding Facility

- 2013/2014 Breeding Season
  - 1 male was chosen to alternate between 2 harems and SCR calculated:
    - Single-Harem Breeding Season
      - 2012/2013
        - SCR- 71.4%
        - 7 sexually mature females
        - 5 births
    - Alternating-Harem Breeding Season
      - 2013/2014
        - SCR- 66.7%
        - 15 sexually mature females
        - 10 births

Sire Conception Rates

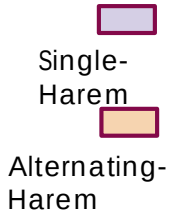
Breeding Season	Male A	Male B	Male C	Male D	Male E	Male F	Male G
2011/ 2012				2/ 3			
2012/ 2013	5/7	10/15	5/5	6/7			
2013/ 2014	10/15	5/6	3/7	5/8	1/1		
2014/ 2015	8/15	7/8	7/9	9/12	5/7		
2015/ 2016	8/12	4/9	6/11	8/13	6/7	8/11	4/4
2016/ 2017	14/22	8/9	3/3	8/13	7/10	13/15	4/7
Single-Harem SCR	**71.4%**	**71.4%**	**73.3%**	**72.2%**	**100%**	**72.3%**	**100%**
Alternating-Harem SCR	**62.5%**	**73.1%**	**65%**	**65.8%**	**81%**	**86.7%**	**57%**

Single-Harem

Alternating-Harem

Results

Breeding Season	Average SCR	Average Number of Births	Average Number of Sexually Mature Females
Single- Harem Breeding Season	74%	4.8	6.4
Alternating- Harem Breeding Season	68.5%	7.7	11.2



Discussion

- Variation for each male
  - Group Dynamics
    - Intragroup fighting
    - Relationship with females
  - Environmental Factors
  - History/success of females
  - Example:
    - Male 3
      - Single-Harem SCR 42.8% vs. 100%
    - Male 2
      - Alternating-Harem SCR 40.8% vs. 88.9%

Future Plans

- Continue to alternate males when needed
  - No significant difference in SCR
- Short-term solution
  - Reduce number of years males can breed within colony
  - Males go through introduction more frequently
    - High stress
    - Increase for wounding at introduction

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Keith Howard- Veterinary Technician
James Martin- Veterinary Technician

VOEN Analytics Conference 2018

Impact Summary

Title: ***Comparison of Sire Conception Rates in Rhesus Macaque (Macaca mulatta) Males Between Two Harem Breeding Arrangements***

Problem and analysis method: Sire conception rates (SCR) (births/ number of adult females each male had access to during the breeding season) of seven males were compared between single-harem breeding seasons and alternating harem breeding seasons.

Summary: SCR during single-harem breeding seasons was 74% compared to 68.5% during alternating-harem breeding seasons. Males were housed with access to an average of 4.8 additional females during the alternating-harem breeding season, resulting in an average of 2.9 additional births.

Impact of the analytics study

Decisions made/Actions Taken: When access is limited to breeding males, alternating male rhesus macaques between harems is an effective breeding management procedure in order to allow more females access to males for breeding.

Calculated or actual Improvements:

Animal Welfare *reduced stress and fighting associated with combining unfamiliar harems.*

Resource use *reduced hours required by veterinary and technical staffs for treating wounds sustained during combining harems. Decreased time required by behavioral staff to monitor new groups. Increased the number of females with access to males, thus increasing overall birth rates.*

Cost avoidance *sexually mature females no longer sit fallow for a breeding season (per diems- food, staff pay (technical, veterinary, and behavioral). Allowing all sexually mature females access to a breeding male increases overall birth rates- revenue for the farm.*