Rochester Academy of Science

BULLETIN

"An organization of people in the Natural Sciences"

June- July 2021; Vol. 75, #5

President's Message

Thank you to all who gave a vote of confidence in your Board of Directors and Academy officers. You have elected Michael Richmond to his first full term on the Board and reelected Tim Tatakis. Our very able and long-serving Helen D. Haller and William Hallahan will continue as corporate secretary and treasurer, respectively. Dan Krisher, who runs our Speakers program and covers for me when necessary, will serve a third term as our V.P., promising to bring more outstanding speakers for our spring and fall sessions. I will do my very best to again preside over our many programs.

47th Annual RAS Fall Scientific Paper Session November 6.

Call for RAS Member Abstracts

In the midst of pandemic turmoil and societal strictures, we were forced to cancel last year's RAS Scientific Paper Session for the first time since its founding. We could find no way to make it work virtually and were advised by our professorial contacts that the students were under far too much disruption to take advantage of it, even if we could. However, with expert predictions that mass vaccines will have the COVID-19 threat under control by July, we are in high hopes that the 2021 session will exemplify the "return to normalcy" so desired by us all. We are scheduled to be at Nazareth College on Saturday, November 6th.

As a member of the Academy with scientific interests, you are invited to present a poster or short talk. Are you working on projects, made any discoveries or been active in a citizen science activity? We'd like to hear about it!

More information about the paper session and how you can sign up to present will be forthcoming on the RAS website and in the next Bulletin later this summer. In the meantime, think about what you might present! If nothing else, plan to come to hear about the latest local research in fields of interest to you and to hear our annual Larry King Memorial Lecture.

Save the Date!
Saturday, November 6, 2021
RAS Scientific Paper Session
Nazareth College

With the coming of fine weather and ever-relaxing social rules, get out and enjoy the natural world around you. Take advantage of our field trips, our observatory, and collecting opportunities. I hope to see you in the field. Meanwhile, I have to make arrangements for a summer field season in Montana!

Michael Grenier, President RAS

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Annual Spring Lecture

We recorded "The Wondrous World of Fireflies" talk at our April 13 annual meeting by Dr. Sara Lewis. If you didn't see the talk, it is at: https://youtu.be/u67Da1QQyEs. The recording started a little late and is about an hour long.

Recent Firefly Evolution Research

By Michael Grenier, RAS President

Photinus pyralis

There are over 2,000 species of fireflies known worldwide and new species are still being discovered. It is said that more than twenty species of firefly are known to live in New York state (*source Finger Lake Land Trust among others*). *Photinus pyralis*, the common eastern firefly, is the most abundant. Taxonomists organize fireflies (beetle Family Lampyridae) into seven sub-families, with much debate about whether there are more or fewer families and whether named species are valid or not. For example, *Photinus* is a member of the Lampyrinae sub-family (see chart on next page).

Photinus pyralis

All known firefly larvae are bioluminescent, but not all adults are. The larvae use bioluminescence to warn predators of their toxicity.

(*Continued on page 4*)

Events for June 2021

For updates to events, check the Academy website http://www.rasny.org and section websites.

NOT MEETING IN JUNE

Mineral Section – members will be contacted if opportunities arise. Contact Jutta Dudley, juttasd@aol.com.

1 Tue: Fossil Section Meeting

7:30 p.m. The meeting will feature a presentation by Dr. Scott MacLennan, with geologic evidence for Cryogenian Icehouse Earth & global glaciation ~751 Ma ago. Visitors welcome. Meeting will be held remotely via ZOOM and is open to all RAS Members and guests. Contact Michael Grenier at paleo@frontier.com for meeting details and logon info.

4 Fri: Astronomy Section Meeting

7:30 p.m. Meeting held at the Farash Center with seating limited to normal capacity only for those already vaccinated. If unvaccinated then with masks and social distancing or outdoors only. We will attempt to stream the meeting via BigBlueButton or other. Speaker: David Bishop. Topic: "Astronomy Year in Review" Meeting details will be shared via email. Contact: Mark Minarich at mminaric@rochester.rr.com.

9 Wed: Astronomy Board Meeting

7:00 p.m. Meeting to be held at the Farash Center. Remote attendance via BigBlueButton as option. Meeting details will be shared via email. Contact: Mark Minarich at mminaric@rochester.rr.com.

10 Thu: Annular Solar Eclipse at Dawn

5:31 a.m. – 6:36 a.m. ASRAS will provide PUBLIC safe, projected viewing from: Charlotte Pier/ Ontario Beach Park, Rochester, NY, Martin Road Park, Henrietta, NY, and Hamlin Beach Park. Contact: Mark Minarich at mminaric@rochester.rr.com.

12 Sat: Astronomy Section Member Observing

Starting from dusk till last person leaves. If unvaccinated then with masks and social distancing or outdoors only. Bathroom rules are posted. Members may bring guests, but all must sign in at Wolk Building for contact tracing. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For cancellations or changes contact Mark Minarich at mminaric@rochester.rr.com or see:

13 Sun: Astronomy Public Open House

12:00 p.m. - 4:00 p.m. (or later, if skies are clear). Observatory tours and work parties. Indoors at normal capacity for those already vaccinated. If unvaccinated then with masks and social distancing or outdoors only. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich: (585) 257-6042 or see www.rochesterastronomy.org/calendar-of-events.

16 Wed: RAS Board Meeting

7:00 p.m. Picnic and facility tour. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. Contact: Michael Grenier at mgrenier@frontiernet.net.

19 Sat: Life Sciences Field Trip

10 a.m. Mendon Ponds Park visitor center parking lot. Tour Wild Wings and a nearby trail walk. Contact: Larry Hirsch 429-6199 or lph710@yahoo.com.

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Fossil Section Field Trips
Date and Time to be Determined:

Collecting field trip to **Little Beard's Creek.**
Collecting field trip to **Portland Point**
For final details, including date, meet-up time, and precautions to be taken, contact Dan Krisher at DLKFossil@gmail.com.

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"Galaxy", Astro Imaginings by ASRAS Member Paula Santirocco

Acrylic, 30"x40". This, and other paintings, jewelry and poetry by Paula Santirocco can be found at her eGallery: https://www.paulasgallery.com/. ASRAS/RAS discounts available. Contact at ps@paulasgallery.com.

Events for July 2021

For updates to events, check the Academy website http://www.rasny.org and section websites.

NOT MEETING IN JULY

Astronomy Monthly Meeting
Life Science Field Trip
RAS Board Meeting
Mineral Section – members will be contacted if opportunities arise. Contact Jutta Dudley, juttasd@aol.com.

7 Wed: Astronomy Board Meeting

7:00 p.m. Farash center Ionia with remote option. Meeting details will be shared via email. Contact: Mark Minarich at mminaric@rochester.rr.com.

10 Sat: Fossil Section Field Trip

Collecting field trip to Swamp Road Field , Morrisville, NY. Oatka Creek Formation. For final details, including meet-up times and precautions to be taken, contact Dan Krisher at DLKFossil@gmail.com.

10 Sat: Herbarium Workshop

10 a.m. – 2 p.m. basement of the Rochester Museum and Science Center (RMSC). At RMSC go to the front desk to meet other participants and sign in (for covid tracing). After a long pandemic pause, the Life Sciences section will hold a workshop at the RAS Herbarium. Must be fully vaccinated to attend, due to the close quarters. You may bring a lunch. If you plan to attend, please send an RSVP to Elizabeth Pixley. For more information, contact Elizabeth Pixley, herbarium curator at 334-0977 or eypixley@gmail.com).

10 Sat: Astronomy Section Member Observing

Start from dusk till last person leaves. Those unvaccinated must observe social distancing and masks. Rules for bathroom are posted at the facility. Members may bring guests, but all must sign in at Wolk Building to facilitate contact tracing. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich: (585) 257-6042 or see: www.rochesterastronomy.org/calendar-of-events.

11 Sun: Astronomy Public Open House

12:00 p.m. - 4:00 p.m. (or later, if skies are clear). Observatory tours and work parties. Unvaccinated must observe social distancing and wear masks. Rules for bathroom use are posted at the facility. Members may bring guests, but all must sign in at Wolk Building to facilitate contact tracing. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich at mminaric@rochester.rr.com or see http://www.rochesterastronomy.org/calendar-of-events.

18 Sun: Fossil/Mineral Picnic

2:00 p.m. kickoff. Wolk building at the Ionia Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. , contact Dan Krisher at DLKFossil@gmail.com.

24 Sat: Fossil Field Trip

Collecting field trip to Jaycox Run, Geneseo, NY. Middle Devonian Ludlowville and Moscow Formations. For final details, including meet-up times, and precautions to be taken, contact Dan Krisher at DLKFossil@gmail.com.

COMING SOON

RocheStarFest. August 27-28, Ionia, NY. Virtual Main Speaker: Alex Filippenko, Ph.D., Professor of Astronomy, UC, Berkeley, Sunday Aug 28th at 7:00 p.m. For details, contact minaric@rochester.rr.com.

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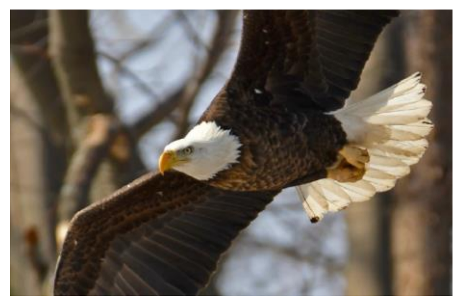
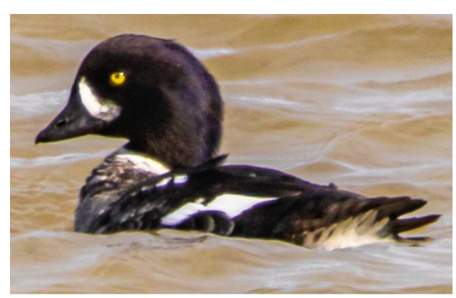
Long Eared Owl, one of 2 seen in the same tree at Braddock Bay Owl Woods, March 23, 2021. Photo by Jay Greenberg, Rochester Birding Association.



Bald Eagle, Eastman-Durant Park, March 10, 2021. Photo: Alan Bloom, Rochester Birding Association.



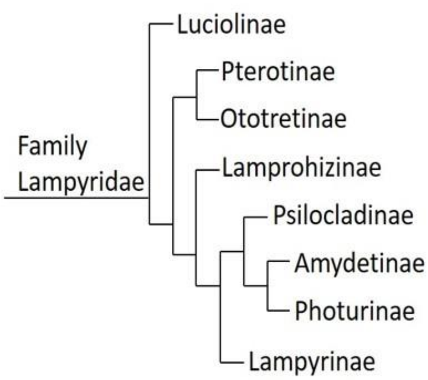
Barrow's Goldeneye, Charlotte, March 5, 2021. Photo: David Lalacona, Rochester Birding Association.

Recent Firefly Evolution Research
(Continued from p. 1)

Recently (2017), a Brigham Young University research team led by Dr. Gavin Martin analyzed the DNA of 82 Lampyridae and seven out-group taxa (species) to determine their evolutionary history and family tree (phylogeny). The DNA of 29 of these was captured for the first time. A traditional character analysis based on morphology was performed to improve on the phylogeny that they estimated from the DNA.

They found that bioluminescence in adults evolved multiple independent times (up to six times) and that it was then lost independently in several lineages (possibly as many as ten times). They also found that prior taxonomy was quite good, with Lampyridae demonstrated to be monophyletic, and subfamilies Photurinae, Luciolinae, Ototretinae, Amydetinae, Cyphonocerinae, and Lampyrinae all highly supported as valid and monophyletic, though the team identified four mis-assigned taxa in the latter that were pulled out.

The following phylogeny at the subfamily level summarizes the team's findings.



en.wikipedia.org/wiki/Firefly#Systematics

This phylogenetic chart (cladogram) is read such that the species ancestral to all fireflies (Lampyridae) gave rise to at least one species that was the ancestor of all fireflies in the Luciolinae subfamily and at least one ancestral to all others. From the latter was derived a lineage that split to form the Pterotinae/Orotretinae clade and another from which the remaining families descended.

(This article concludes next month with reports on fireflies and the "molecular clock" of DNA change rate and on fireflies in the Age of Dinosaurs.)

Reference

Martin, G.J., et al. Total evidence phylogeny and the evolution of adult bioluminescence in fireflies (Coleoptera: Lampyridae). *Molecular phylogenetics and evolution* 107 (2017) 564-575.

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Synchronization in Nature – From Fireflies to Tidally Locked Planets.

by Theodore W. Lechman, RAS Bulletin Editor

It is commonly recognized that ordered systems become disordered over time, that randomness increases, and that this is state of affairs is enshrined by the second law of thermodynamics. This is not the whole story, however. There are many situations where order actually increases – where randomness decreases. Randomness decreases when natural oscillators are able to affect the frequency and phase of similar neighboring oscillators. This facility of systems of oscillators to converge in frequency and phase is known as *synchronization* [1]. In dynamical systems theory, such synchronization is achieved via the mechanism of "nonlinear coupled oscillators" which is the subject of this article.

Examples of synchronization are everywhere in nature. Although the precise mechanism of their synchronization may be vastly different – quantum mechanical, hormonal, electrical, chemical, social, gravitational, etc., nonetheless their mathematical descriptions as a dynamical system are identical. Examples of such synchronization schemes are: electronic phase-locked loops (ubiquitous in computer, control, and communications systems), lasers and masers, Josephson super-conducting junctions, coupled mechanical oscillators such as mechanical pendulum clocks, the flashing of fireflies, the flocking behavior of birds, menstrual cycles of mammalian females, synchronized claw waving in fiddler crabs, synchronized respiration in honeybees, synchronized chewing in termites, synchronized activity cycles and alarm drumming in ants, neuronal electrical firing between neurons in the brain, coordinated firing of cardiac "pacemaker" cells, the tidal-locking of planets, and the social and linguistic trends, customs, and fashions in societies.

At the April 13th RAS annual meeting, the featured speaker – Dr. Sara Lewis gave a talk on "The Wondrous World of Fireflies". In it she mentioned that male fireflies in mangrove forests of Malaysia congregate on trees and synchronize their flashing. To witness this phenomenon for yourself, please see the video at [3].

Fireflies are a type of beetle that use bioluminescent chemicals in their abdomens to emit light flashes to attract females for mating. It turns out that only males synchronize their flashes and do so only when in groups – these groups can be as large as 1000's of fireflies. These groups of fireflies have no central leader or conductor – there is no global communication between fireflies; each firefly is affected only by its immediate neighbor. This synchronized firefly flashing is an emergent global behavior resulting from individual behavior.

The behavior of an individual firefly resembles that of an oscillator. Figure 1a shows the individual behavior of an isolated firefly at night. It can be seen that from a baseline energy level, the bioluminescent molecules in the firefly abdomen are linearly charged with energy until the energy level reaches a certain threshold value, at which time the firefly releases most, but not all, of the energy as a light flash of a certain short duration. The remaining energy is linearly discharged as heat, or other chemical

(Continued on p. 5)

Synchronization *(Continued from p.4)*

reactions, at a faster discharge rate and shorter discharge time than the charging rate and period. The average period of a flashing firefly is approximately 965ms +/- 90ms (~10%).

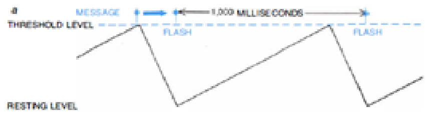

Figure 1a: Firefly charge, flash, and discharge cycles. [4]

In the presence of neighboring flashing fireflies, of the same species so that their natural flashing frequency is roughly the same (within 10%), the flashing fireflies will converge to flashing at the exact same frequency as well as the exact same phase. The number of cycles its takes to synchronize is roughly 20 on average, with closer fireflies taking less time to synchronize, and farther away fireflies more time – if they can synchronize at all.

The way firefly synchronization works is basically as follows: if two fireflies flash at the same time, there is no change in flashing in either. If a neighboring firefly flashes near our firefly while our firefly is in the middle of its charging (rising) ramp, that external flash will cause our firefly to abort its charging sequence and return to baseline and restart the charging cycle again. This consequently delays the flash of our firefly by the amount of time it spent charging before the charge-abort. See figure 1b.

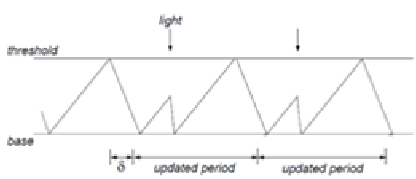

Figure 1b: Phase Delay model of firefly flashing: charge abort. [5]

If on the other hand, a neighboring firefly flashes near our firefly after our firefly has flashed but is still in its discharge period, then the remaining energy being discharged gets immediately dumped to baseline, and the next charging cycle begins prematurely. This consequently advances our firefly's next flash by the amount of time the discharge (falling) ramp was foreshortened, as seen in Figure 1c.

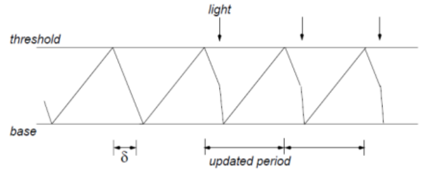

Figure 1c: Phase Delay model of firefly flashing: discharge abort. [5]

What was just described is known as the "Phase Delay" firing model. This is the firing model exhibited by *Photinus pyralis* as well as cardiac pacemaker cells and neural inhibitory networks.

A different kind of firing model, shown in Figure 2, is the "phase advance " firing scheme, exhibited by the tropical *Pteroptyx malaccae* and *Pteroptyx cribellate*. In this scheme, if a neighboring firefly flashes near our firefly, this will induce our firefly to immediately start flashing, cutting short the previous cycle's charging or discharging sequence, restarting the cycle earlier. This firing scheme only progressively advances our firefly flashing cycle and never delays it.

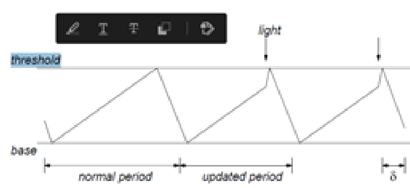

Figure 2: Phase advance model of firefly flashing. [5]

Regardless of which firing model is being utilized, the net result is that both fireflies (or neurons, or oscillators in general) synchronize to each other and therefore to a common frequency and phase. Distribute this effect across the entire group of fireflies and you have the entire group of fireflies flashing synchronously to a single frequency and phase.

In effect, each firefly acts as an individual oscillator, exhibiting periodic and repeating cyclical behavior. This is "nonlinear" because the change of frequency and phase of each "oscillator" is NOT proportional only to its own frequency and phase, but to the difference in frequency and phase between it and all of its neighbors, which are influenced in turn: it's a very large system of simultaneous nonlinear equations.

Another example of frequency and phase locking between "oscillators" is the tidal locking between the earth and the moon. This results in the same face of the moon always facing the earth, due to the moon's period of revolving around the earth being equal to its rotational period – these two phases are "phase locked" due to the gravitational pull between the earth and a slightly equatorially bulging moon. See Figure 3.

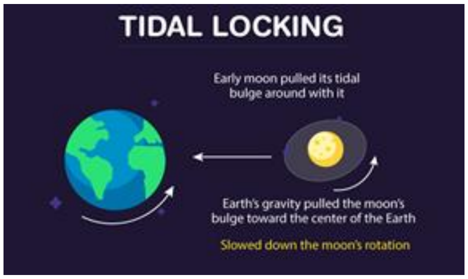

Figure 3: The moon tidally locked to the earth. [6].

But can oscillators frequency and phase lock only if their frequencies are close to each other? It turns out that two oscillators whose frequencies are far apart but are exact ratios of each other can also synchronize. The classic example is the tidal locking between the planet Mercury and the Sun, where for every 3 rotations of Mercury around its axis, it also revolves around the Sun 2 times, and this results in a 2:3 phase lock. This means that Mercury presents the same face to the Sun every OTHER revolution.

A more mathematical representation of this in terms of oscillators is as follows: if there exists a frequency f_s such that osc_2 is at $f_2 = 3f_S$, and osc_1 is at $f_1 = 2f_S$, then the two oscillators will phase lock with a beat period of f_S. This implies that $3\tau_2 = 2\tau_1 = \tau_s$, as seen in figure 4 below.

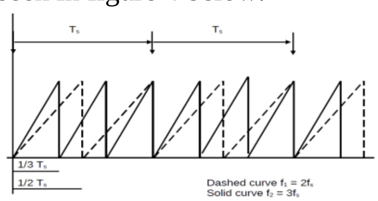

Figure 4: Two Ramp functions in 3:2 beat period. Arrows indicate beat period. (author)

(Continued on p.6)

Synchronization*(Continued from p.5)*

Dynamical Systems Approach

All the synchronizing systems mentioned and described previously can be characterized by a simple mathematical expression:

$$\frac{d\theta_i}{dt} = \omega_i + \alpha_j \sin(\theta_j - \theta_i) \qquad (1)$$

This states that the frequency of oscillator i, that is – the rate of change of oscillator i's phase, is dependent not only on the normal constant frequency that oscillator i would run at if isolated, ω_i , but is also dependent on the phase difference between oscillator i and the neighbor oscillator j that is affecting it. The coupling strength is represented by the coupling coefficient α, and is dependent on factors such as nearness, ambient light, and so on.

These two oscillators can be readily visualized by considering two runners, A and B, on a racetrack, where the two runners normally run at different speeds. Ignoring the other's speed, they will normally overlap each other at a period depending on their relative frequencies. But if they try to run together, say, to be able to converse, then the faster runner will gradually slow down and the slower runner will speed up until they synchronize in frequency and in phase.

It should be noted that the coupling term, $\sin(\theta_j - \theta_i)$, is zero at the values: $\theta_j - \theta_i = 0, \pi$, and $-\pi$. At these values, the coupling term disappears.

Similarly, at $\Delta\theta = +$ or $- \pi/2$, the coupling is at its strongest positive or negative effect.

The exact dynamics of the coupled oscillators described by equation (1) depends on the relative amplitude of ω and α. Figure 5 below shows three cases.

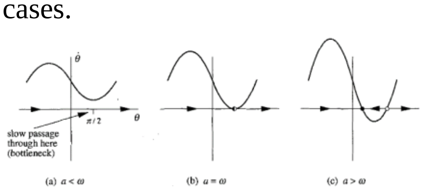

Figure 5: The 3 dynamical modes of a coupled oscillator in equation 1. [2]

Figure 5a shows the case when α < ω, corresponding to an overdamped system. In this case the oscillator coupling is such that the oscillator goes faster or slower than its normal frequency but never has to stop or reverse to catch up with the other oscillator. Its maximum velocity above normal is at $\Delta\theta = -\pi/2$, and its minimum velocity below normal happens at $\Delta\theta = +\pi/2$, known as the "bottleneck".

Figure 5b shows the system when α = ω, also sometimes referred to as "critically damped". The oscillator actually comes to a full stop and may stay there if the coupling oscillator θ_j stays at rest at some particular phase.

Figure 5c show the situation where α > ω, that is the system is underdamped. In this situation the coupling is so strong that it causes the oscillator to actually reverse direction to catch up with the coupling oscillator. This is equivalent to the two-runner track situation, where the faster runner actually reverses direction, not just slows down, to catch up with the slower runner, and likely overshoots the slower runner in the other direction.

Another way to look at it is in terms of the frequency difference of the two oscillators:

$$\frac{d\phi}{dt} = \frac{d\theta_j}{dt} - \frac{d\theta_i}{dt}$$

$$= \Omega - (\omega + \alpha_j \sin(\varphi)) \qquad \text{(eqn 2)}$$

Where Ω the isolated frequency of oscillator i, ω is the frequency of oscillator j , and φ is simply the phase difference between two.

Let $\mu = \frac{\Omega - \omega}{\alpha}$, then eqn 2 becomes:

$$\frac{d\phi}{dt} = \frac{d\theta_j}{dt} - \frac{d\theta_i}{dt}, \text{ or}$$

$$\frac{d\phi}{dt} = \mu - \sin(\phi) \qquad \text{(eqn 3)}$$

The graph of this dynamical system is shown in figure 6a-c below.

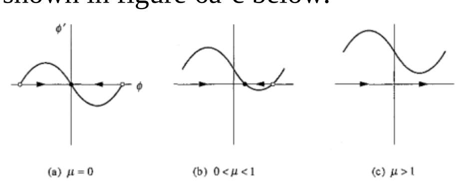

Figure 6: ϕ' vs ϕ, equation 3. [2]

This depiction treats the two oscillators as a single system, characterized by the difference in frequency and phase of the two oscillators. Figure 6a shows the situation when the difference in frequencies of the two oscillators equals the coupling coefficient between the two oscillators. In this case, the system is stable, and any perturbation causes the system to return to the origin, restoring synchronization and phase lock. That is, the firefly and its stimulus flash simultaneously, in phase lock, because the firefly is driven at its natural frequency.

Figure 6b shows the case when 0 < μ < 1. In this case the oscillators lock frequency but lock phase at a constant phase difference greater than 0. Thus, the firefly's rhythm is phase-locked to the stimulus but at a fixed non-zero phase difference. Phase locking means they run at the exact same frequency but not in unison.

Finally in figure 6c we have the situation where both frequency and phase synchronicity are lost – that is, we have lost phase lock. The phase difference is constantly increasing, and the frequencies never match.

References

[1] Synch: The Emerging Science of Spontaneous Order, Steven H. Strogatz, Penguin Press, 2004.

[2] Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, Steven H. Strogatz, Perseus Books, 1994, Chapter 4.5, pp. 103-106.

[3] Synchronicity (Thailand) : Experiment in the mangrove forests of Thailand. Thousands of live fireflies are made to synchronize their flashes with a few computer controlled LED's. https://www.youtube.com/watch?v=ZGvtnE1Wy6U

[4] Buck, J. and Buck, E., Synchronous Fireflies. *Scientific American* pp. 74-85. (May 1976).

[5] Daeeum Kim, A spiking neuron model for synchronous flashing of fireflies. BioSystems 76, 2004, pp. 7–20. [doi 10.1016_j.biosystems.2004.05.035]

[6] https://byjus.com/physics/dark-side-of-the-moon/

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Featured 2020-2021 Undergraduate Student Research Grant Award Winner

Alicia Addams, Canisius College, *Novel Versus Constant Scent Lure Methods: an analysis of scent lure effectiveness at camera trapping stations*.
Sponsor: Robin Foster, Ph.D., Assistant Professor of Animal Behavior, Ecology, and Conservation, Canisius College.

Abstract

Understanding the impact of non-invasive methods used to monitor wildlife is essential in maximizing the effectiveness of wildlife management. One important variable is understanding how scent lures can be used at camera trap stations to increase capture rates and detectability. Through this project I will examine whether mammals are intrigued by the scent itself, or whether the novelty of the scent is what draws the animal to the lure. I will utilize several scent types on a rotating basis and compare the success of this scent regime to that of a consistent scent lure.

Three treatment types will be applied to cameras placed in Allegheny State Park. These will consist of a control with no scent, a constant scent, and a rotating scent. The role of scent novelty in camera trapping applications is relatively unexplored. This study will help to determine the most effective form of scent lure usage when paired with camera trapping and improve our understanding of wildlife responses to these lures. This may be crucial for maximizing the success of field studies by decreasing the potential of wildlife habituation to scent lures.

Scent lures are a tool most often used in conjunction with camera traps. Together, they are the leading non-invasive method for animal surveys. Until now, most research has focused on whether animals are drawn to certain types of scents, with some studies analyzing how animals respond to scents on various land types [4]. However, research has not been done to understand how the novelty of stimuli plays a role in attractiveness to lures at camera trap stations. A study specifically observing coyotes looked at how they reacted behaviorally to novel stimuli but understanding these reactions with regards to field study success still remains unresearched [3]. Studies such as these suggest that novelty is an important aspect in animal activity. Further research can show how biologists can exploit the curiosity of animals for the benefit of conservation. My study will analyze the idea that scent novelty could yield higher camera trap captures, optimizing camera-based studies. I hypothesize that animals are not necessarily attracted to scent lures because of the scent type but are actually attracted to the novelty of the scent.

My study will employ three treatment groups. A control group will be the first treatment, with no scent lure being applied to the camera stations. The second treatment group will have a constant scent applied for the duration of the study. The third treatment group will consist of camera stations with scent lures that are changed every two weeks after placement. Three scents commonly used in camera-based studies will be rotated at each camera assigned to treatment three: a commercial berry scent, Obsession for Men by Calvin Klein, and Fatty Acid Predator Discs. For the Calvin Klein and no scent groups, a small fabric disc will be used to provide visual consistency between treatments. I predict that introducing a novel scent into the environment will result in an increase in the detection rates of animals on camera traps, with reduced time until first detection, reduced distance from the lure, and increased time spent in front of the camera. If this hypothesis is correct, we would expect to see a reoccurring uptick in detection rates when each scent is first applied to treatment three, while treatment two would have a decrease in capture rates over time due to habituation to the consistency of the scent.

Camera stations will be set in areas of similar habitat type, with recognizable signs of animal activity. The study will take place from May 1st, 2021 through September 4th, 2021. A fully crossed factorial design will be used, with three cameras being placed at each of the ten sites (one for each treatment). Cameras at each site will be placed 250 meters apart to prevent the scent from one camera affecting another. Additionally, study sites will be at least 1 km apart to prevent animal habituation to the alternating scents if the stations overlap in the animal's home range [2]. A total of 30 cameras will be utilized in the study. One camera at each location will be prescribed one of the three treatment types for six weeks. Every six weeks, the treatment will be moved to a new camera within that site. Lures for all stations will be refreshed after two weeks. Detection probabilities for each species present will be determined using Bayesian occupancy modeling. Specific behaviors, such as orientation toward the scent, time spent at each scent station, and interaction with the scent will also be analyzed.

Through this study I expect to provide a fresh, new outlook on scent lure use. By capitalizing on the attraction of mammals to novel stimuli, camera trap effectiveness may be improved. Understanding the nature of mammalian responses to scent lures is vital for a researcher's ability to maximize the effectiveness of camera trapping studies. My scent lure investigation will ultimately contribute to the overall success and

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efficiency of camera-based wildlife research and represents an important step in moving beyond an understanding of why animals respond to scent lures, rather than simply identifying scents that may attract certain species.

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