

## 15th European Symposium for the Protection of the Night Sky

### To all speakers:

Please note that the time for your talk is 15 min plus 5 min discussion and setup for the next talk! Please deliver your talk (preferably on USB memory stick) before your session!

### Abstracts:

**Sunday 2022, May 1<sup>st</sup>**

#### **Under One Sky: growing the global dark sky movement**

*Ruskin Hartley, Executive Director, International Dark-Sky Association*

The global increase in light pollution is well documented. And its impact on astronomy, wildlife, energy waste, public health and wellbeing is increasingly understood, with more studies published every month. Despite this, light pollution continues to be poorly understood by the public at large and the elected officials that represent them. But that is starting to change with the growth of the dark sky movement globally. Through our programs, the International Dark-Sky Association supports thousands of volunteers in 60+ countries worldwide. Many are pursuing the certification of International Dark Sky Places - there are now more than 200 of these place-based demonstrations of good lighting worldwide. I'll review the movement's status, discuss opportunities to support its continued growth, and explore ways to accelerate progress towards our shared goal of restoring the night sky.

#### **The making of the International Dark Sky Reserve UNESCO Biosphere reserve Rhön**

#### **The making of the International Dark Sky Community Fulda**

*Sabine Frank, Sternparkbeauftragte Landkreis Rhön*

*Andreas Hänel, Working Group Dark Sky Germany, ahaenel@uos.de*

We report about the first ideas to the realisation of the two dark sky places.

## Eye In the Sky – Optical Remote Sensing

Noel PNG, MSc (Engineering Mechanical), Alba Orbital – Remote Sensing

### INTRODUCTION

The world that we live in today is a world of light. Light is used everywhere, by everybody, and for everything. There is no escaping it. Where ever you go, there is always a glow of light shining from somewhere. Prior to the modern world, the Earth and life on it used to be controlled by the natural cycle of day and night, light and dark. “Someone once said that the 24-hour ... rhythm evolved because the Earth revolved.

The cycle is a universal characteristic that is shared by all animals, insects and even bacteria[3]. But, as in so many other instances, we humans have managed to manipulate and interrupt nature, and with the help of technology take over control of it. In order to take better advantage of night-time and to use it for other purposes, we have filled darkness with artificial light. But this kind of disregard for nature does not come without consequences.

### CAUSE AND EFFECTS

The cause of ALAN generally is attributed to rapid population growth and urbanisation across cities. Using datasets made available by NOAA/DMSP-OLS and the regression function *ee.Reducer.linearFit()* in google code editor, the follow timelapse imagery from the reference year 1991.

The reference code is featured in the Appendix. The changes in light intensity from light green to yellow between 1992 and 2012 indicates rapid urbanisation trends and a general increase in light emitted from major cities across Europe.

The effects of ALAN is unfortunately pervasive in every aspects of human living conditions and the surrounding natural environment. There exists a plethora of literature on the adverse effects of ALAN. It is not the intention of this paper to delve into the specifics.

### PROPOSED METHODOLOGY

The general demonstrated capabilities of round the clock monitoring by Satellites have been proven. Notable examples include missions from the European Space Agency (ESA) for the Copernicus scientific programme involving Sentinel 1,2,3 and 4. The proposed methodology involves the use of PicoSatellites that adhere to the Pocket Cube standard. This standard follows a size of 5 cm with a mass of no more 1 kg. The relative low cost of manufacturing such Satellites make it relatively affordable for mass production.

The table below summarises the key remote sensing capabilities of the PicoSatellite.

	<b>Present</b>	<b>Targeted</b>
<b>Resolution</b>	24 m GSD	10 m GSD
<b>Spectral Bands</b>	Red , Green, Blue	
<b>Image Size</b>	62 km X 48 km	
<b>Sensitivity</b>	600 m V / Lux - sec	
<b>Frequency of Passover</b>	28 days	15 minutes
<b>Existing Satellites in Space</b>	4	Constellation fleet

The PicoSatellites are manged directly with its own accompanying ground station manged by Alba Orbital. Currently, one station is operated in Germany with a second station planned for deployment in the second half of this year.

The locations for the ground stations have been carefully selected with Satellite Mission Trajectory simulations performed in NASA's GMAT (General Mission Analysis Tool). The figure below is a screen capture of the Mission Analysis user interface showing an arbitrary orbit of a single Satellite around the Earth. This allows Satellite operators to gauge the estimated number of pass overs within a day to maximise the downlink for optical imagery.

## **JUSTIFICATIONS FOR PROPOSED METHODOLOGY**

While there are open source public data sets for night imagery available, the specifications it offers has its associative limitations. The figure on the top of the next page summarises the key shortcomings in three often utilised data sets. An absence of relatively excellent resolution rates and the general lack of calibration presents a huge challenge for academics and commercial users who require refined imagery of places at night.

With the launch and deployment of four Earth Observation Satellites, the estimated imagery to be obtained would likely be comparable to the image on the bottom next page. This image was obtained from the ISS (International Space Station) at an estimated resolution of 24 m GSD (Ground Sampling Distance).

## **CONCLUSION**

The proposed methodology to combat ALAN is by no means a water tight approach. Ultimately what is required to address this perennial problem is a combination of social governance policies in the form of legislations mixed with technological approaches such as those adopted by Alba Orbital.

## **What a cheap camera can add to sky quality measurements compared to single-channel instruments?**

*Zoltán Kolláth, Eszterházy Károly Catholic University, zkollath@gmail.com*

In places with low levels of light pollution, the measured sky radiance strongly depends on natural processes: the intensity of airglow and the transparency of the atmosphere. We perform a spectral sky survey at different locations to get reliable information on the spectral variability of natural night sky radiance. We found that the prominent lines (green oxygen: 558 nm, orange sodium: 589 nm and red oxygen: 630 nm) change strongly and independently. Since the spectral response of different sensors differs for these colours, the spectral variability results in a biased measurement depending on the colour ratios.

We also measure the radiance of the night sky by fixed digital cameras at the Hungarian dark sky parks. We found a 40% variability in sky brightness in a single week period in a recent measurement sequence. The weather condition was stable primarily during this period; thus, the variation should have been originated from the natural changes in airglow. The variation of the green-to-blue ratio (G/B) confirmed the above hypothesis. G/B was decreased from 1.5 to 1.3, with the decrease in sky radiance. Parallel spectral data confirmed the variation of the spectral content of airglow measurements. From the measurements by a single-channel device alone, we cannot tell the cause of variation. We propose methods and software solutions to make corrections to single-channel measurements based on accompanied digital photography.

## **Fear and Crime**

*Dunja. Storp*

How much light does safety need?

Hardly anything is linked to the concept of safety and the feeling of security as much as the topic of light or lighting. It is often suggested, that more light automatically leads to MORE safety, which is not true in view of the complex influences of light on humans. This results in a clear need for safety-focused lighting design with intersecting planning geometries, which is in striking synchronicity with nature.

## **Sky brightness monitoring in the Rhön/Fulda**

*Marc Streit*

We will report about the installation of measurement network for the sky brightness in the UNESCO biosphere reserve Rhön and the city of Fulda.

## **How to make a luminaire Dark Sky friendly**

*Jens Schütte, Adolf Schuch GmbH, [jens.schuette@schuch.de](mailto:jens.schuette@schuch.de)*

Abstract: A best practice for Dark Sky friendly lighting is using a so called „Technical Luminaire“. A Technical Luminaire is a fully shielded luminaire emitting no light above the horizontal plane. Unfortunately it is not always possible or desired to use Technical Luminaires. Therefore we investigated how luminaires not meeting Dark Sky requirements can be modified in order to be suitable for approval.

Commercial luminaires comply with IDA's requirements for Dark Sky Approved products („Fixture Seal of Approval“) when the uplight is both less than 0.5% of total output and less than 50 lumens, with no more than 10 lumens in 90-100 degree UL zone.

A so called „Decorative Luminaire“ usually has an uplight of several percent. Through a combination of appropriate measures, it was possible in many cases, to reduce this percentage below 0.5%. Some examples will be shown and explained.

## **Efficient and Sustainable Dark Sky Lighting - Dark Skies & Sustainable Communities**

*Kerem Asfuroglu ([kerem@dark-source.com](mailto:kerem@dark-source.com))*

Dark Source is a London-based lighting design practice driven by social and environmental values. We work with communities and local authorities of various kinds in the pursuit of achieving dark skies. Our experience in dark sky friendly lighting design has repeatedly shown us the important and powerful role of the community located at the heart of each project. These projects achieved results which are both socially and environmentally sustainable. Besides reducing the environmental impact and energy waste, these communities created a sense of local pride which promoted a new set of values resonating with a greater audience.

The presentation will include projects such as Plas Y Brenin in Wales ([Video](#)), Presteigne Dark Sky Masterplan in Wales ([Video](#)) and Cloughjordan Ecovillage in Ireland. The talk will feature a mixture of finished and ongoing practical examples conveying the strengths which can be derived from working closely with a community in order to achieve lasting results.

## **Protection of the Night in Austrian World Heritage Sites**

*Günther Wuchterl, Christoph Goldmann Kuffner-Sternwarte, Naturhistorisches Museum, Wien*

The "Dürrenstein Wildernis" and the "Kalkalpen National Park" were added to UNESCOs world heritage list in 2017.

We describe efforts and results of long term monitoring for the sites from 2010 to 2022 and report median night and night-sky conditions and trends.

We summarize the results from the project "Lebensraum Naturnacht" that pioneered the measurement of light in night-habitats as monitoring, communication and management tools including efforts to link the night-habitats with the exhibition in the Vienna Natural History Museum. That includes authentic full-dome representations of selected habitats. [Sample projections are shown if a full dome system is available].

We summarize the direction- and area-complete measurements of Vienna's light sources from two helicopter campaigns and the results of a decade of monitoring of Vienna's light and possible correlations with atmospheric parameters, including those related to air-quality.

Finally we present the first results from a year of night-measurements at the Sonnblick high altitude observatory, that will connect light-monitoring measurements to the Austrian "ARAD" high-accuracy radiation-monitoring network.

## **Astronomical tourism: the beauty of the sky as a resource for territories**

*Stefanie Pontasch, PhD, Tyrolean Environmental Ombudsoffice, Innsbruck,*

The SKYSCAPE ITAT 2047 project is supported by the Interreg Italy-Austria 2014-2020. It intends to protect and develop the intact night as a natural and cultural heritage of certain territories in Austria and Italy. The Tyrolean Environmental Ombudsoffice is coordinating activities in the Kaunertal Valley to preserve and enhance the quality of the night by creating astro-touristic offers to allow a deep and lasting experience under the night sky. The process of certification by International Dark Sky Association is initiated in the Kaunertal valley.

The presentation will give an overview on the approach, results of Astro-touristic installations, actions, products and offers as well as progress of IDA-certification process in Tirol.

## **Environmental impact of highly polarized dark water at the harbour of Lake Balaton**

*Dénes Száz, Ádám Egri, György Kriska, Gábor Horváth, Department of Biological Physics, ELTE Eötvös Loránd University, H-1117 Budapest, email: szaz.denes@gmail.com*

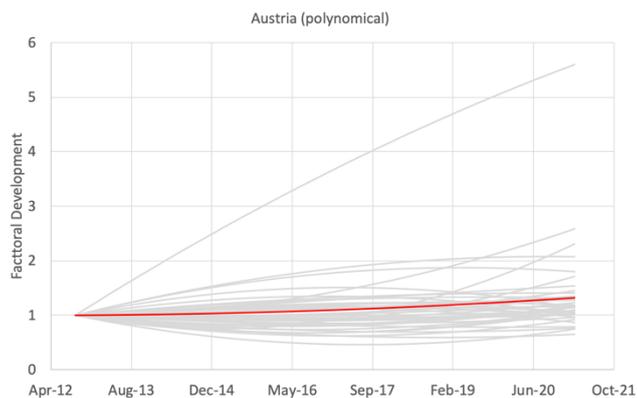
The polarized light pollution of dark artificial surfaces reflecting highly and horizontally polarized light usually have negative effects on polarotactic aquatic insects detecting their habitats by the horizontal polarization of water-reflected light. We have observed that the water between the concrete walls of a harbour of the Hungarian Lake Balaton is continuously dark from autumn to spring due to the inflow of a canal rich in dissolved humic substances. With imaging polarimetry, we demonstrated that this dark water patch reflects light with higher degrees of polarization than the brighter lake-water. According to our hypothesis, the stronger polarization signal of the dark water patch is more attractive to non-biting midges (Chironomidae) - which are native to this region of the lake - than the surrounding brighter lake-water. With larval samplings, we showed that both the density and the average size of chironomid larvae were significantly larger in the harbour than in the surrounding lake. This finding may represent an ecological advantage of polarized light pollution: polarotactic chironomids are intensely attracted to a strongly and horizontally polarizing, seasonally dark water patch at the canal outflow, where the abundance of larvae increases. As a novel technique, we also used drone-polarimetry to measure the polarization of the water patches from above to demonstrate the attractiveness from the point-of-view of flying insects. With this method, we could also search for possible other beneficial light-polluting locations around Lake Balaton.

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## A brief glance on the development of light pollution in Austria over a decade

Stefan Wallner,<sup>1,2</sup> and Sarah Stidl<sup>1</sup>, Department of Astrophysics, University of Vienna, Tuerkenschanzstrasse 17, 1180 Wien, Austria, <sup>2</sup> ICA, Slovak Academy of Sciences, Dúbravská cesta 9, 845 03 Bratislava, Slovak Republic, [stefan.wallner@univie.ac.at](mailto:stefan.wallner@univie.ac.at)

A very important parameter for quantifying the development of light pollution in specific areas or even countries is the light growth rate, indicating an overall increase or decrease of the amount of light received by detectors. Ground-based observations, provided by light monitoring networks (e.g., Sky Quality Meters) have shown to enable small scale analyses of long-term trends with minor areas solely to be characterized in greater detail. In order to make statements about national policies regarding artificial light at night, whole country territories must be contemplated. Past studies have shown that satellite imagery (e.g., VIIRS) appear to be the best option to do so. Over a national scale, this potentially includes areas with high discrepancies in their radiance values, i.e., urban areas being very bright and rural areas very dark. Furthermore, for light emitting areas, also the spectral sensitivity of satellites can lead to distorting effects on long-term trends as cities continuously undergo lighting changes. With those impacts in mind, this work concentrates on the question, if only areas with no or extremely low amount of emitted light can serve as indicators for the light pollution development in a whole country, as such are usually not producing light themselves but suffer from peripheral influences. As a first step, in order to check this, we analyzed light-trends of all 48 nature parks in Austria over the past decade and check their trend towards an increase or decrease in radiance values. Results show that in those nature protected spaces the amount of light increased by an average of  $\sim 30\%$  over the last ten years with some areas showing an increase up to  $\sim 550\%$  with only few decreasing. We will highlight those examples and also talk about ongoing projects being performed in the country.



## **DARK SKY AND THE ARTS – a personal testimonial**

*Teddie Hwang, flutist and photographer, [teddie.hwang@gmail.com](mailto:teddie.hwang@gmail.com)*

*Website: [www.teddiehwang.com](http://www.teddiehwang.com)*

The night sky has inspired art and culture since ancient times. Through the practice of astrophotography, I became aware of the common threads between the dark sky experience and music, and these connections reveal some of the most important concepts in music.

The ideas of light and dark and the technique of long exposure are parallel to essential aesthetics in classical music, such as playing with varied expression and internalizing a piece of music over time. Musical interpretation is about understanding beyond written notation, which is similar to how long exposure allows us to see beyond our physical limitations. To surrender oneself to the elements is an act of humbleness, a key quality for a performer.

I use the above concepts in masterclasses to educate musicians on how to become compelling storytellers. In addition, the dark sky is a source of inspiration for projects and interdisciplinary collaborations with other artists, as music festivals are increasingly interested in bridging music with other disciplines. For example, I will be performing and co-presenting a talk with dark sky educator Georgia MacMillan at the Galway Early Music Festival this May, demonstrating the social and cultural importance between science, environmentalism, and the arts.

This presentation is a personal testimonial on how the night sky has influenced and redefined my musical trajectory, and is a gesture of appreciation and gratitude for all those involved in the dark sky movement.

## **The two dimensions of reducing light pollution**

*Sabine Frank, Landkreis Fulda, [Sabine.Frank@landkreis-fulda.de](mailto:Sabine.Frank@landkreis-fulda.de)*

Nearly every advocate for more dark skies is confronted with two dimensions: First, the failures in the past that led to many unnecessary or incorrectly designed and installed lighting systems. On the other hand, the fear that this trend will continue uncontrolled with the development of further construction areas. To make natural sky protection effective, both dimensions must be addressed. This presentation aims to identify strategies for both dimensions. With regard to existing lighting, the example of cooperation with the Chamber of Commerce and Industry will be used to present a promising possibility. Addressing the future, the instrument of urban land use planning will be discussed, in order to better control the development of light pollution.

## Challenges in Avoiding Unsustainable Road and Street Lighting

Aleš Šubic, *Initiative for Regulation of Outdoor Lighting, Slovenia, ales.subic@gmail.com*

Road/street lighting is one of the key contributors to the light pollution and visual space degradation. It is seen as acceptable and almost as a must in all types of settlements, also the smallest ones and in many cases it's installed even along connection roads between the settlements. Under the influence of lighting standards and recommendations its intensity and uniformity represent a major environmental and spatial burden in non-urban areas. In such areas a decision for no lighting should be done much more often. Where the lighting is installed, a major advance, related to the standard EN 13201 based lighting is, if it's only orientational. At least within settlements, the first option doesn't have a sufficient theoretical and administrative background and in long term it's hardly achievable. Orientational lighting is not an option as well, as soon as standard EN 13201 is used. The second major problem are transit regional roads, where the extent of illumination is typically high and the lighting is again influenced by the mentioned lighting standard, which in such cases is used even more strictly than in local environments. An example of an important challenge is illumination of low-grade regional roads through dispersed settlements. In this regard, the question arises as to what we expect from road/street lighting at all. Is it only traffic safety, personal and property security, a sense of security, comfort ...? And further from that we have to estimate, which of these needs are relevant for certain locations, for which we can afford to meet them, if we want to preserve the environment and space and what are the proper uniformity and intensity levels for particular types of locations.

**Monday May 2<sup>nd</sup>**

## **The influence of artificial light at night on the Outstanding Universal Value of the Wadden Sea World Heritage**

*Krop-Benesch, A. <sup>1)</sup>, Nazzari, C. <sup>2)</sup>, van der Graaf S. <sup>3)</sup>.*

- 1) Initiative Nachhaltig Beleuchten, Berlin*
- 2) Common Wadden Sea Secretariat, Wilhelmshaven*
- 3) Programme Towards a Rich Wadden Sea, Leeuwarden*

The Wadden Sea is a unique area with a variety of interconnected terrestrial and marine habitats. It is the world's biggest intertidal area and an important part of the East Atlantic bird migration route, with up to 12 million birds present yearly. As a natural World Heritage site, the protection of its biodiversity has high priority.

It is known that ALAN poses a threat for migratory birds and is one factor in the reduction of insect populations. However, little attention has been paid on the impact of artificial light at night on intertidal and marine areas. Intertidal areas are highly rhythmic environments, in which organisms need to synchronise with daily, lunar, seasonal, and tidal rhythms. ALAN can interfere with this synchronisation. The consequences are mostly still unknown.

To better understand the relationship between light emissions and the Outstanding Universal Value of our World Heritage, PRW commissioned, within the Trilateral Dark Sky Initiative, in collaboration with the Common Wadden Sea Secretariat and the Partnership Hub, we conducted a review of scientific literature and present an overview of the known and suspected effects of ALAN on organisms in the Wadden Sea area.

## **Keep it Dark - A Tri-Lateral Initiative to Monitor the Darkness of the Wadden Sea Region**

*Peletier, R.<sup>1)</sup>, Kjeldsen H.<sup>2)</sup>, Noel-Storr J.<sup>1)</sup>, Jurriens T.A.<sup>1)</sup>, Haenel A.<sup>3)</sup>, Drolshagen G.<sup>4)</sup>, Hüppop O.<sup>5)</sup>, Nazzari C.<sup>6)</sup>, van der Graaf S.<sup>7)</sup>, Poppe B.<sup>4)</sup>*

- 1) Faculty of Science and Engineering, University of Groningen
- 2) Department of Physics and Astronomy, Aarhus University
- 3) Working Group Dark Sky Germany
- 4) Faculty for Medicine and Health Sciences, Carl von Ossietzky University Oldenburg
- 5) Institute of Avian Research, Wilhelmshaven
- 6) Common Wadden Sea Secretariat, Wilhelmshaven
- 7) Programme Towards a Rich Wadden Sea, Leeuwarden

The monitoring of various measurable parameters is an essential part of the ongoing efforts to protect and support the management of the Wadden Sea as an ecological entity and its World Heritage status. Although the region has remained one of the darkest in Europe, the loss of nocturnal darkness constitutes a challenge for the preservation of the World Heritage Site. Therefore, due to the growing evidence that light pollution affects various aspects of an ecosystem, a systematic assessment and permanent monitoring of light pollution is important to complement the current conservation efforts. .

In this initiative, partners from three Wadden Sea countries plan to set up a network of ground-based measuring stations, which will be supplemented by other data (such as satellite measurements). A set of at least color channel differentiating detectors that can be used as input parameters for further scientific investigations, e.g. for ecological-biological studies shall be installed. To give both the policy makers and the public the necessary information to evaluate the development of light pollution in the Wadden-Sea region other, possibly simpler, measurement systems might be considered, so that darkness measuring systems can be rolled out in the future at low costs and without many technical difficulties.

Our roadmap foresees two steps: in a first phase, the appropriate measurement devices and metrics will be identified and compared at selected pilot stations within the region. In addition to complex methods (Astro-CCDs with filters, DSLR), the usability of already established systems, such as the Dutch system “Donkerte van de Wadden” or the Allsky-Camera Networks FRIPON and ALLSKY7 will be analyzed.. In the second phase, the network is then to be put into operation in a build-up phase. Throughout the process, relevant stakeholders (science, society, management authorities, policy makers) will be involved.

In this work we will report on the current status of our initiative.

## **Donkerte van de Wadden - Multipartner darkness awareness cooperation in the Dutch Wadden area**

*T. Jurriens*

### **Reduce Light – Just do it!**

*Andreas Hänel, Working Group Dark Sky Germany, ahaenel@uos.de*

Some years ago we have formulated the following aims to reduce light pollution:

- Install artificial light at night(ALAN) only if necessary
- Use as faint light as possible
- Direct the light where it is needed, especially not towards the sky
- Reduce or switch-off light according to the needs
- Use environmental friendly lighting colors

We describe some examples where we tried to study and follow these rules during the last years, in International Dark Sky Places but also in other places.

## **Towards insect friendly road lighting**

*Isabell Charis Wuthenow, Umweltzentrum Fulda,*

The project “Species Protection through Environmental Friendly Lighting” (AuBe) is researching the possibility of protecting insects using a new lighting design for road luminaires. Optimized lamp shielding is intended to reduce stray light into the trajectory of insects and thus the attraction effect of the lamps. Conventional luminaires attract insects and trigger a so-called “vacuum cleaner” effect, which causes insects to be “sucked out” of their ecological functions to the light source. Nocturnal habitats can be fragmented by light barriers from poorly shielded luminaires. The light emitted by luminaires should therefore only be visible where it is needed: On sidewalks or streets. The light will no longer be visible at the luminaires’ head, because a new type of shielding will minimize the “vacuum cleaner” effect at the luminaire.

Once a month during the waning crescent moon, insects will be collected at the four trial sites and identified with the help of citizen scientists. After the 2022 season and before the 2023 season, the lighting will be converted to the newly developed design, and some of the lighting will remain in the old condition. This will allow insect conditions to be compared two years before and after the modernization, and in a direct comparison at four different sites. The project ends in 2024 with the goals of introducing the newly developed insect-friendly road lighting design into municipal practice, offering a guide for insect-friendly lighting in public spaces, and creating a deeper awareness towards light pollution.

The project is a joint initiative for the protection of nocturnal insects, coordinated by the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB, Berlin) in cooperation with the Department of Lighting Technology at the Technical University of Berlin and partner cities and municipalities: Star City Fulda, Neuglobsow at Lake Stechlin (Gransee Office), Gülpe in Havellaaue (Rhinow Office) and the town of Krakow am See, as well as its nature park Nossentiner /Schwinzer Heide.

## **Association Sternenpark Rhön e.V.**

*Simon Manger, Sternenpark Rhön*

The Sternenpark Rhön e.V. is an association in which volunteers work to preserve the dark night. Through guided tours, we educate people about light pollution and bring them closer to the starry sky. We cooperate with the administration of the Rhön biosphere reserve and Rhön GmbH (tourism) to promote the protection of the night sky.

## **Plight With Light Initiative ([www.hellenot.org](http://www.hellenot.org)) – information and recent activities**

*Stefanie Suchy, Tyrolean Environmental Ombudsoffice, Innsbruck,*

The long-term project „plight with light“ of the Tyrolean Environmental Ombudsoffice started in 1999. The main objectives are (1) to draw attention to the negative effects of artificial light at night and (2) to provide criteria and recommendations for the responsible use of outdoor lighting, especially with regards to common applications and technical solutions. All criteria developed on the „plight with light“ platform have to be met in standard administrative proceedings concerning the natural environment, where the Environmental Ombudsoffice has legal party status. Past and present subprojects include for example a travelling exhibition (2017-2019), the support and measuring of a floodlight replacement (2021) and our current information campaign, addressing light pollution as a stress factor for wild animals with the help of cartoons.

## **Artificial Light at Night affects behavior and gene expression in an insect model**

*Levy Keren<sup>1\*</sup>, Wegrzyn Yoav<sup>1</sup>, Efronny Ronny<sup>1</sup>, Fishman Bettina<sup>2</sup>, Tauber Eran<sup>2</sup>,  
Barnea Anat<sup>3</sup> and Ayali Amir<sup>1</sup>*

<sup>1</sup> *School of Zoology, Tel Aviv University, Tel-Aviv, Israel*

<sup>2</sup> *Department of Evolutionary and Environmental Biology, University of Haifa, Israel.*

<sup>3</sup> *Department of Natural and Life Sciences, The Open University of Israel, Raanana, Israel*

[kerenlevy@mail.tau.ac.il](mailto:kerenlevy@mail.tau.ac.il)

The natural light-dark cycle is the major signal entraining the circadian clock, regulating physiological and behavioral rhythms in all organisms. Artificial Light at Night (ALAN) disrupts the perception of this cycle and negatively impacts animals at various levels. We studied the effects of different lifelong ALAN intensities on the behavior of *Gryllus bimaculatus* crickets, a model of insect physiology and chronobiology. Adult male crickets were exposed to 12h daylight (40 lx), and one of four night-conditions: complete darkness (LD), ALAN of 2 lx or 5 lx, and constant light (40 lx). Stridulation and locomotion of individuals were simultaneously monitored for five consecutive days and nights. The period, median, variance, and acrophase of the daily activity rhythms were compared among groups. Next, LD crickets were exposed for 30 minutes, 3h into the night, to a light pulse of 2 – 40 lx. Following RNA extraction, relative expression of circadian genes in various tissues was compared using qPCR. Crickets under LD cycle, showed a rhythm of 24h, stridulating at night and being locomotory active during the day. ALAN affected both the level and timing of activity. An increasing proportion of the animals demonstrated *free-running* patterns, decreasing synchronized rhythmicity in the population. Short ALAN pulses elicited treatment dependent, differential expression of circadian genes in the different tissues. Our findings demonstrate the multi-level effects of ALAN in an insect model.

## **Artificial light at night affects orientation of moths beyond flight-to-light behaviour**

*Jacqueline Degen, [jacqueline.degen@uni-wuerzburg.de](mailto:jacqueline.degen@uni-wuerzburg.de)*

Moths play a crucial role as nocturnal pollinators and are important components of almost all terrestrial food webs. Recently, light pollution has been suggested as a possible driver for insect decline in general and decline of nocturnal moths in particular. The most studied effect of artificial light sources on moths is the “flight-to-light behaviour”, i.e. the attraction to artificial light sources. However, to date it is neither sufficiently understood when and why this behaviour occurs nor whether orientation is affected in general. We used harmonic radar to record trajectories of free-flying moths and linked these to the light environment quantified via all-sky photometry. We found that only 4% of flights ended at one of the six streetlights that were evenly arranged in a circle around the release site in a distance of 85m. Thus, most of the animals did not show flight-to-light behaviour. However, the streetlights had a barrier effect for lappet moths (*Lasiocampidae*), whereas hawk moths (*Sphingidae*) were able to leave the light circle but showed a significantly reduced directionality of flights compared to flights where lights were turned off. Furthermore, the moon as a natural light source generally had a positive impact on orientation performance. Our results show that the impact of light pollution on moths goes beyond flight-to-light behaviour, suggesting that negative effects of light pollution are greater than currently assumed.

## **Lighting surveys with the Nachtlichter app**

*Christopher Kyba & Nachtlichter citizen science team, GFZ German Research Centre for Geosciences  
[kyba@gfz-potsdam.de](mailto:kyba@gfz-potsdam.de)*

Much of the focus in dark sky advocacy over the last several decades has been on street lighting. This is important, as street lights are one of the largest individual sources of light, but they are far from the only source, especially in the early evening. In this talk, I will present the "Nachtlichter" (night lights) app, which was co-created by a team of citizen scientists during 2019-2021. The app is designed to allow you to quickly and easily conduct a lighting inventory while walking from one street corner to another. We used the app to run large campaigns in the fall of 2021, but this talk will be mainly focused on how the app works and how to use it, with only a brief presentation of preliminary results.

## **Astrotourism: How An Emerging Travel Market Can Help Preserve Dark Skies.**

*Michael Marlin (goes by Marlin), Michaelmarlin07@gmail.com*

This talk will share the author's research for his book, "Astrotourism: Star Gazers, Eclipse Chasers and the Dark Sky Movement".

In the span of a single lifetime, light pollution from Artificial Light At Night (ALAN) has severed our connection with the stars that we've had since the dawn of time. With the nocturnal biosphere significantly altered, light's anthropogenic influence has compelled millions of people to seek out the last remaining dark skies creating a new travel market called "Astrotourism" or "Star Tourism".

This talk will cover the growth of the astrotourism, identify star seeker trends, and how sharing the stories in the ways stars have shaped civilizations and our relationship with the night captivates those who are new to a dark sky. Meteor storms, eclipses, auroras, and other celestial phenomena have lured travelers for years and here the field of astrotourism is expanded with the inclusion of astronomical clocks, megaliths, and sundials, which track the movement of the stars.

Technology changes tourism (consider the invention of SCUBA gear) and will continue to do so as it has changed astrotourism. In the 1940's it was labeled 'Astronomy Tourism' and only astronomers (professional and novices) were involved with the pastime. The advent of social media has caused this new travel market to expand exponentially.

With the expansion of space tourism more people will be exposed to the "Overview Effect."

*The overview effect is a cognitive shift in awareness reported by some astronauts during spaceflight, often while viewing the Earth from outer space. It is the experience of seeing first-hand the reality of the Earth in space, which is immediately understood to be a tiny, fragile ball of life, "hanging in the void", shielded and nourished by a paper-thin atmosphere. The effect may also invoke a sense of transcendence and connection with humanity as a whole, from which national borders appear petty.*

It was with the first images of the earth at night from space that people around the world became aware of our luminous footprint and with this new understanding, actions have been taken to bring about the necessary change to curb and mitigate the impact of light pollution

Potential astrotourists are found primarily in metropolitan areas and have interests in planetariums and science fiction movies which are virtual forms of astrotourism. As a natural resource is monetized in a capitalistic society, the tendency is to preserve and protect what would be seen as "priceless", but holds a value that can lift impoverished areas with the spread of the tourist dollars in otherwise over-looked locations.

Dark Sky Initiatives can do the following-

- 1) Reduce Light Pollution
- 2) Reduce Energy Costs
- 3) Reduce Energy Consumption
- 4) Reduce Greenhouse Gases
- 5) Improve Safety
- 6) Protect Nocturnal Wildlife
- 7) Protect Human Health

8) Provide Economic Stimulation

9) Preserve Cultural Heritage

10) Improve Aesthetics

Astrotourism is a way to reach a much wider audience who would become advocates of dark skies in much the same way SCUBA divers become advocates to protect the oceans and duck hunters are one of the most effective groups preserving wetlands in North America.

Currently 'astro-economies' are springing up around large telescopes that are put into place by the scientific community. Such examples are the SALT in South Africa and the numerous installation on the Atacama Desert. The future may unfold where 'astro-economies' come into place much in the same way Fringe Festivals, that was originally an off-shoot of the Edenborough Festival, have spread across the world with hundreds now in operation.

## **Slovenian light pollution legislation - consequences after 15 years**

*Andrej Mohar / Dark-Sky Slovenia*

## **The potential for a European federation of night protection associations**

*A. Sánchez de Miguel<sup>1,2</sup>, Ruskin Hartley<sup>1</sup>*

*1 International Dark-Sky Association*

*2 Cel Fosc*

Across Europe, there are a growing number of groups and individuals engaged in protecting the night sky from light pollution. Some of the challenges faced at the European level include the implementation of the EN13201 road lighting standard versus the ALARA (As Low As Reasonably Achievable) levels, the possibility to turn off streetlights when possible, the inclusion of outdoor light in environmental impact assessments, and an approach to addressing transnational light pollution. A critical mass of interest and resources are required for effective action at the EU level.

The potential for coordinating different organizations working to control light pollution in Europe is excellent. Progress can be accelerated by identifying and expanding successful programs and strategies, enhancing cooperation, and coordinating efforts. An IDA-Europe organization, or self-coordinated partnership with IDA, would be ideal due to the many IDA chapters in Europe and the potential for global coordination.

We seek input during the forum on a handful of questions to shape this concept:

- What role should IDA play to support the dark sky movement in Europe?
- What can IDA do that no other entity is doing?
- What role could an IDA-Europe play?

## Poster:

### **Effect of light pollution on plant morphology, physiology and the species composition of plant communities.**

*Kornél Baráth, Magdolna Dani, Flóra Siska, Anna Skribanek, Department of Biology, Savaria University Centre, Eötvös Loránd University, [barikori@gmail.com](mailto:barikori@gmail.com); [skribanek.anna@sek.elte.hu](mailto:skribanek.anna@sek.elte.hu)*

Light pollution has a harmful effect on both terrestrial and aquatic ecosystems. In this study, the effects of light pollution on plant morphology, physiology and the species composition of plant communities were investigated.

The settlement of Bárdudvarnok provided a perfect location for the research. In 2018 there were 16 lampposts with CFL (compact fluorescent lamps) lighting and 15 columns without luminaires in the settlement, in the same habitat type. The plant communities within a 5-meter circle under lampposts and lampless columns were compared in terms of species composition using principal coordinate analysis (PCoA) with the Jaccard coefficient. Multiple Response Permutation Procedure (MRPP) was also conducted with the Jaccard coefficient to test differences in species composition among plots. In our studies, we also examined the leaf morphological, leaf anatomical and photosynthetic changes of *Erigeron annuus* and *Fallopia x bohemica* herbaceous species on light pollution.

Based on the results of PCoA and MRPP, the species composition of light-polluted and non-light-polluted areas was not separated from each other. In our experience the wavelength range of CFL lamps supports the photosynthetic activity of the studied species and the growth of palisade tissue cells, which play a key role in leaf photosynthesis, increasing plant biological production.