RWL Case-Study

Country:
Slovenia
Provider:
Društvo Temno nebo Slovenije, Dark Sky Slovenia
http://www.temnonebo.org/

Name of the programme?
Together for a natural, starry sky

Age of the children involved?
12 to 15 years; the programme can be adapted for secondary-school students as well.

Short Introduction
Humans need light, but exaggerated and inappropriate lighting has a variety of negative consequences. Energy consumption has unnecessarily increased, natural processes are disturbed, we are facing long-term health risks and astronomical observations are hindered. Night-time lighting decreases or even stops production of melatonin (sleep hormone) in people, animals and plants. Melatonin is a strong antioxidant and it intensively regenerates the organism and inhibits the formation of cancerous formations such as breast and prostate cancer. Artificial light also has a negative impact on nocturnal animals. Light attracts insects, especially if it includes the part of the spectrum with shorter wavelengths (mostly ultraviolet and blue light). When caught in light beams, moths do not feed or reproduce and are more exposed to predators. Lighting disturbs bats on their flight paths. It delays the time of their emergence from roosts and negatively influences the availability of prey (insects). As a result, female bats as well as their offspring have poorer nourishment, making it harder for them to survive the winter. Light pollution is considered one of top 10 factors which endanger biodiversity.

What is the frame?
There is a reason that night-time is dark and we should try to keep it that way for the benefit of our health and the world around us.

What are the goals of the programme?
The main goal of the programme is to bring attention to the little-known problem of light pollution and the effects of night-time illumination on human health, biodiversity and on astronomic observation. Another goal is suggesting solutions for reduction of light pollution and breaking the myth that more light means better safety.
Further goals:

- Recognizing that light pollution as an environmental issue, understanding the value of biodiversity and gaining a basic understanding of the ecology of nocturnal animals.
- Developing attitudes and relationships: awareness of the value of biodiversity and of the sensitiveness of the night environment; formation of positive and responsible attitudes to nature and respect for all forms of life.
- Understanding the influences of environmental and technical sciences on how society develops, and on nature preservation.

- Ability to recognize and understand environmental issues; taking a responsible and active part in preserving the environment and creating sustainable practices.

What values are promoted in the programme?

Respect for nature and care for the state of our planet:

Because of humans' anthropocentric view of the world around them, it is difficult to encorage young people to respect nature for nature itself. Therefore our programme is set in a way which shows clearly nature's value for humans. In the case of light pollution the emphasis is on considerate use of lighting. The adaptation of lighting is one of the factors contributing to the conservation of biodiversity and thus the stability of ecosystems. In this way, the programme indirectly also plays a role in preserving free ecosystem services.

Equal opportunities for all people to shape their lives:

Information and knowledge are the key factors for young people to understand that artificial lighting influences their quality of life, their health directly and also indirectly through the environment. Understanding this is the basis for behaviour change and later on for getting involved in the democratic processes.

Respect for future generations:

In the long run only high biodiversity ensures the stability of ecosystems, and the quality of lives of the future generations depends on these ecosystems.

Which competences are promoted that empower learners to shape a sustainable future?

- Enable learners to cooperate, participate, take responsibility and learn in a self-directed way One of the goals of working with students in 'Together for natural, starry sky" programme is to help them understand natural laws, and being a part of the natural environment and the society. Through the activities students develop skills for functioning in society and become aware of the importance of working together with the natural world. Based on the understanding of the connections between humans and the natural environment, students can form high moral standards and follow the precautionary principle when needed. All this is a foundation for their future engagement in decision-making process and for successful sustainable management.
- Enable learners to deal with their own feelings and the feelings of others
  For students it is almost impossible to overcome their fear of darkness without using a flashlight. Through this programme they learn about human eye's incredible adaptability to darkness. While participating in the activities they have an experience of managing the surroundings at night.
- Enable learners to be reflective and critical thinkers – considering different perspectives to reach informed opinions and decisions
  Light pollution is generally a little-known environmental problem. This programme is probably the first opportunity for students to hear about this issue. It opens up a whole series of new view-points and questions, which the general public is only just starting to be aware of. People's desire for comfort, safety and progress is always linked to technical solutions, and these solutions are a result of different disciplines (electrical engineering, physics, mechanical engineering, etc.), but they rarely take into account the environmental effect of these technical solutions. Therefore besides the technical solutions, students are given the basic knowledge of the ecology of nocturnal animals, and the importance of sleeping in a dark environment for human health. The programme also introduces them to the magic of the starry sky through astronomical observations. Newly acquired knowledge and experiences enable students to consider their relationship with their surroundings.
- Allow learners to take ownership of their learning and reflect on what and how they have learned
  Through students' sharing their knowledge and experiences of the effects of artificial light on humans and animals, with their family and friends, new questions will arise and they will search for answers for these questions. In this way they strengthen their knowledge and understanding of the topic.
- Empower learners to be creative, flexible and able to take positive action to deal with change Students share the new information and knowledge with people around them and together they recognize

problems and try to find appropriate solutions. A part of this is also being able to find appropriate lamps for home usage or letting neighbours know if their garden or driveway lighting is set wrongly.

- Enable learners to become conscious of interconnectedness – you, me and the world around us
  Learning about light pollution and its long-term effects on biodiversity is best demonstrated through observation of nocturnal animals in different lighting conditions. This helps students to lose their prejudices against bats and to realize that moths, at first sight boring night-time butterflies, are insects who have excellently adapted to nocturnal life and who have beautiful colours and unusual shapes.

Which of the specific scientific concepts does the programme relate to?

Cycles: Through the millions of years of evolution, organisms have adopted to the cycle of light and darkness, which ensures stability of functioning of organisms (including human health), connections between species and the functioning of ecosystems.

Change: Changing parameters like night-time lighting means an interruption in systems, to which organisms cannot adapt within a reasonable time.

Energy flow and Stability: While these changes have negative effects on reproduction, migration and the feeding of animals, they also affect stability of food chains and webs and through this they disturb the stability of the ecosystems.

Which ecological problems are involved, if any, and how? (Refer to mindmaps of 9 planetary boundaries)

The programme relates to different environmental issues:

- Biodiversity loss which is also connected with the conservation of ecosystems: Students know what biodiversity and ecosystems are, but they often do not sufficiently understand their own influence on them and the importance of the ecosystem services. Through the programme they understand how some ecosystems influence human every-day life and also humanities long-term survival.
- Climate change: Students are reminded that our comfort is linked with electricity consumption, including illumination and production of lamps. Energy consumption of developed countries is constantly growing (including Slovenia). Expecting that we might obtain all the necessary energy from renewable sources is an illusion, and this results in an increase in the amount of greenhouse gases emitted. This consequently leads to climate change. When today's students grow up, they will be the decision makers, including decisions such as the strength of illumination in our cities, what to illuminate and how densely the street-lighting should be.
- Waste management (Chemical pollution): Students understand why we separate waste and are actively involved in this. In the programme their attention is drawn to waste electrical and electronic equipment, which includes incandescent light bulbs and all kinds of lamps. When planning street-lightning, the decision-makers (who, of course, were not included in this programme) do not pay adequate attention to the question of whether, after a certain period of time, only a light-bulb will have to be changed or whether whole street-lamps will go to waste, since changing certain parts on each lamp would be too expensive.

Transferability: Which different areas of learning are included and how?

- Encourage active transfer during and after the experience:
  Active transfer happens on its own since the emphasis of the programme is on guided observation and the activities take place outside of usual time-frames. After the activities a discussion takes place and the experiences are placed into a rational and emotional frame.
- Related to global society:
  Emphasis is put on global dimensions of light pollution and its negative effects.
- Related to learners' communities:
  Students can use their knowledge and initiative to influence decisions about lighting in their homes. As they grow up they can be active citizens who address the problem and have control over decisions associated with public lighting.

- Related to the man-made environment:
  Nowadays we have made daylight at night-time in many places. We need to strive towards finding again the natural biorhythm of day and night. Also, when investing in lighting, energy efficiency should not be the sole criterion – we need to consider lights that are also nature friendly.
- Related to living nature:
  Having the knowledge and possibility to choose, we should choose lighting which is friendly to nocturnal animals.
- Related to the learners themselves:
  An individual can improve his quality of life by equipping himself with knowledge and experience, which can be the foundation for behaviour change (for example: we find solutions which enable us to sleep in the dark).

What educational strategies (learning models, methods, etc.) are used in your programme?

1. Explanation: The programme starts by motivating students on the topic and for then to take an active part in the programme. This method enables students to learn about the basic elements of the issue and to understand its complexity.
2. Projection and presentation: This method is used when to realistically present examples from nature or situations cannot be done under present circumstances.
3. Observation, perception and sensing (field work): Students carry out the prepared activities independently or in cooperation with the teacher. They use all their senses, which enhances their cognitive abilities.
4. Research - getting results / samples: Each task includes a question, which can only be answered by gathering enough information through observation. With the help of this information, students can explain certain concepts and principles and learn new concepts and skills.
5. Role play enables students to focus on a specific problem. Being personally involved helps them to realize more effectively their own and others' points of view, emotions and actions. Through this they internalize the issues addressed.
6. Discussion: Each concrete activity (own experiences, thinking process, new findings) triggers questions, which can be answered through a dialog. The teacher adds information, and comments, links students' opinions and summarizes them. This method is also used for reviewing new knowledge, forming conclusions, emphasising new information and developing students' skills and abilities.

How is the programme evaluated? How do you know the programme achieved its educational goals?

This programme is in the phase where different activities and sets of activities are being tested with groups of students. Therefore it is difficult to evaluate it at this time. The teachers' responses prove that the programme is needed, because after every workshop new requests are sent in. The novelty of the topic has proven as a motivating factor for both students and teachers, because the topic is not a part of formal or informal education.

Describe the programme.

The programme 'Together for natural, starry sky' tries to equip students with knowledge and information, which are needed to understand light pollution, the little-known environmental issue, and to look for measures and solutions for reducing this problem. A variety of activities is carried out to familiarize students with the life of nocturnal animals and their significance for nature and people. Students are encouraged to pay attention to illumination sources, which have until now been considered a benefit of civilization with no environmental impacts. The programme also tries to demonstrate the incredible ability of a human eye to perceive small amounts of light.

Activities:

1. Learning about the abilities of a human eye:
   People have scotopic (night) and photopic (day-light) vision. The human eye is better adapted for seeing in light conditions; therefore we have well developed cone cells, which are responsible for colour vision.

Night-time vision is mostly black-and-white and is produced through rod cells. Nocturnal animals have a much higher number of rod cells than day-time animals, which affords them good night vision.

- Measuring the smallest amount of illumination which still enables us to read and differentiate colours

2. Sources of light pollution:
   Despite having modern public lighting, street-lights are often too strong and set too close together. Over the last 20 years illuminated advertisement boards have become another problem.
   - Photographing street-lights and determining which ones are environmentally friendly
   - Finding over bright or uneconomical lighting
   - Making a list of advertisement boards which have a high energy consumption.
3. Biodiversity of nocturnal life:
   INSECTS are attracted by light. Once they are caught in a beam of light, they stop eating and reproducing, and being in the illuminated area makes them a much easier prey to predators. This adds to other reasons for the continual decrease from generation to generation in the size of the populations of insects. Facades with weaker directed illumination attract about 10 times fewer moths than stronger illumination which shines in all directions. The results also show that warm yellowish light attracts fewer insects than bluish light, and is therefore less disturbing for them.
   - Observation of insects on illuminated and unilluminated surfaces.
   - Observation of the activities of insects on surfaces with different colour lamps.
   - Observation of the activities of insects in tents designed for attracting moths, with different types of lamps.

   BATS are amongst most endangered mammals. Lesser horseshoe bats can often be found in churches which are not illuminated under the condition that there are big enough gaps for them to fly out of. In situations where they live in an illuminated church they usually use gaps which are unilluminated.
   - Observation of bats flying out
   - Observation of differences in bat behaviour in the vicinity of different types of street-lights

Included resources / materials / tools.

Activity 1

Measure the lowest illumination, at which you can still read and differentiate colours

Andrej Mohar, Dark-sky Slovenia

The eye is a wonderful organ, capable of adapting to a very wide range of illumination. On the table below there are typical values of illumination.

	Lux (lx)
At noon, when the sun is highest on the sky	130.000
A cloudy day	10.000
Illumination, needed for precise tasks (surgeons, watchmakers, etc.)	3.000
Very thick cloud	1.000
Minimal illumination of a desk in an office	300
Highest allowed illumination for paper documentation (museums)	50
Illumination of a very busy (and illuminated) roads	30
Illumination of a remote road	1

Illumination caused by full moon	0.2
Illumination at which we can still read (differentiates with people – test it)	0.2
Illumination at which we can differentiate colours (differentiates with people – test it)	0.2
Illumination caused by first quarter moon	0.04
Illumination, caused by bright clouds reflecting city illumination	0.01-0.2
Illumination which enables safe walking outside (starlight)	0.001

Equipment:

You need a luxmeter, with a resolution of 0.01 lx and with an illuminated screen (which is very important, since you shouldn't illuminate the luxmeter to read the value).

Description:

Measure the day-time illumination out of doors and within the school, with students.

After the sunset go out to an open location, not shaded by trees, and at least 100m from any street-light or other man-made illumination sources. Students should write down the measurement of the luxmeter every 5 minutes. They should have some reading material with them (a newspaper) and a colour chart (made at least of red, yellow blue and green; it can have other colours as well). Students test the illumination which enables them to read and differentiate colours. When it gets very dark, our eyes only see black-and-white. The values will not be the same for all students.

Warning:

Students should not use torches, because these would interrupt the eyes' adaptation to darkness and would lower the eyes ability to carry the tasks out correctly.

Activity 2

Photographing street-lights and determining which ones are environmentally friendly

Andrej Mohar, Dark-sky Slovenia

During the day take photographs of typical street-lights in your town. Count each type. Determine which ones are environmentally friendly. Calculate the portion of environmentally friendly street-lights in your town.

Equipment:

Digital camera with a telephoto lens.

Description:

During the day take a research walk through the town. Let students take photographs of typical street-lights and count them. They should write down the street where they were observed.

One group should measure or estimate the height of the street-lights and the distance between them. You can do this by counting the steps between them, then measuring your step and calculating the distance.

Criteria for an environmentally friendly street-light:

An environmentally friendly street-light does not emit light towards the sky. Therefore it has flat glass, parallel to the ground. It should not have any additional glass or plastic on the side. Each transparent surface sends the light in all directions and this kind of street-light causes a lot of light pollution.

Students should make a table with:

- The number of streetlights sending light in all directions (round and similar)
- The number of partly shielded street-lights (with convex tops, etc.)
- The number of fully shielded street-lights

Students should calculate the proportion of environmentally friendly street-lights.

Warning:

Students should pay attention to the setting of the street-lights. If they are too far from the edge of the road they probably are not illuminating the road but an area which does not need to be illuminated. They should take notes of examples such as this.

Note:

The difference between full cut-off and fully shielded lamps:

http://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/cutoffShielded.asp

Activity 3

Finding too bright or uneconomical lighting

Andrej Mohar, Dark-sky Slovenia

Students do night-time measurements with luxmeter. They walk a few streets and roads and measure the maximum illumination. They also measure the illumination between the street-lights and on sidewalks.

They make an evidence sheet:

Name of the street:

Measurement of illumination under the street-light:

Measurement of illumination between street-lights:

Students describe whether they think that the street is illuminated enough, or possibly too much. They determine whether the pedestrians and cyclists on the side of the road are clearly visible. They look at pedestrian crosswalks and determine whether they are sufficiently marked (and not faded) and additionally illuminated. Crosswalks need to be additionally illuminated particularly in places where large numbers of pedestrians are expected.

Equipment:

Luxmeter with a resolution of 0.01 lx.

Discussion:

Students are not familiar with the classification of streets and will have problems deciding the appropriate amount of illumination. They can, however express their opinion on how many lux are enough under and between the street-lights for a street to be safe. If a street is very busy with mixed traffic (cars, cyclists, pedestrians), it needs to be intensely illuminated. The street-illumination was introduced to protect pedestrians – cars have their own lights and in principle do not need extra illumination. Therefore most streets, especially outside of settlements, are supposed to have no public lights. If there are no cyclists and pedestrians, lights are not needed.

Ask students to find the street-lights with the stronger illumination. For example – the most illuminated spot in Vienna has 80 lux. For a peaceful side street 1 lux can be enough, a very busy street (for example in centre of Ljubljana) it averages 10 lux. Even the busiest streets should not average more than 20 lux.

Warning:

Night-time group work can be dangerous – not so much due to dark roads, but also drunk drivers. Extra care is necessary and at least people at the beginning and end of the group should be wearing reflective vests.

Activity 4

Making a list of billboards which are very energy consuming

Andrej Mohar, Dark-sky Slovenia

With a use of a camera and a luxmeter, students find energy-consuming and over-illuminated billboards.

Our eyes adapt to any level of illumination. This makes it difficult to determine what is less or more bright. We therefore need a measurement tool.

Equipment:

Camera with a stand

Luxmeter

One way to measure brightness is by putting a luxmeter in front of the billboard. If the billboard has an outside light, we set the luxmeter to its bottom edge, facing towards the lamps which are above it (in Slovenia the law demands that billboards are illuminated from above, with 0% light going upwards). We press the button HOLD so that the luxmeter remembers the measurement. Then we write it down. We compare billboards of different sizes and shapes.

Evidence sheet:

Location of the billboard:

Is it illuminated from above?

Are the lamps set in a manner which prevents the light to go upwards, towards the sky?

Illumination on the bottom edge of the billboard:

Width of the billboard (measured with a tape measure or steps):

Height of the billboard:

Area of the billboard in square meters:

A better method of measuring, or at least estimating, the illumination is with the help of a camera. It is essential that the camera is set on a stand, perpendicular to the billboard. If possible we set it at the distance of at least five times the width of the billboard. If we take the photo of the billboard from close, the measurement often shows less illumination than it is in reality. We use a telephoto lens. The camera has to be set on manual. The settings need to be:

ISO:	400
Aperture	8

For each billboard we take 5 shots with different shutter speeds:

	seconds	if the photo of the billboard is in natural colours, it is...
1. Shutter speed	1/250	very much too illuminated
2. Shutter speed	1/60	much too illuminated
3. Shutter speed	1/15	too illuminated
4. Shutter speed	¼	adequately illuminated
5. Shutter speed	1	environmentally friendly

We take a look at the photographs the next day. The photographs will differ a lot. With very illuminated billboards and a long shutter speed (for example 1 second) the photograph will be unrecognisable. With a bit shorter shutter speed the colours will be too bright – for example green might not be green but whitish, etc. We chose the photograph where colours are best visible. Then check in the table what this says about the amount of illumination of the billboard. However, it is difficult to say that a billboard is environmentally friendly – it would be most environmentally friendly if it weren't there at all. The countries with a high level of concern for the environment have hardly any billboards.

Students can compile statistics of the billboards. Advertisements are not just the billboards but also signs on factories, shopping centres, restaurants, etc.

Activities 5-7

Materials for the teachers
Effect of light pollution on moths

Barbara Bolta Skaberne, Life+ Life at Night

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Society for the Conservation and Study of Lepidoptera

Nocturnal insects

Many nocturnal insects are attracted by light. For orientation they use natural sources of light – the moon and the stars. When they come to a vicinity of a lamp, they often mistake the manmade light for natural light and get caught in circling the lamps. Once they are caught in a beam of light, they cannot break out. Being in an illuminated area makes them a much easier prey to predators then if they were in their natural night-time environment. From the time of being caught in the lamp-light, they stop feeding and reproducing which adds to a lower number of offspring. Artificial illumination is therefore one of the factors for the long-term decrease of size through generations, and variety of species of nocturnal insects. This affects other animals that feed on insects, for example birds, amphibians and bats. Insects are also essential pollinators, another reason why this is a problem.

Since the vital part of their vision is in the ultra-violet part of the spectrum, this light attracts them most.

The activities which are described below:

5. Observation of the number of insects on illuminates surfaces
6. Observation of the activities of insects by lamps with different spectrums
7. Observation of the activities of insects in tents for attracting moths with different types of lamps

Preparation for the activities

All activities have to be well prepared to get the expected results. It is suggested that you prepare workshops with the help of butterflies and moth experts.

Activity 5

Observation of the number of insects on illuminates surfaces

Location:

An illuminated facade of a building. Factors for choosing the observed location:

- As bright illumination as possible
- The smallest number of other visible lamps, besides the ones illuminating this surface
- Flat and unbroken surface – without windows, ledges, etc.
- Sheltered from the prevailing wind, if possible
- The side of the building which is exposed to the sun during the day – it retains heat longer.
- Facing a variety of habitats (ideally a forest) is an advantage
- The size of the observed surface – approximately 2 x 10 m, which can be divided into smaller areas – each pair of students observes one part

Time of observation:

- Mid May to mid September
- For about 30 minutes
- Observation begins at nautical dusk - about half an hour after the sun is completely below the horizon.

Minimal weather requirements:

- The air temperature mustn't be below 10 °C, the ideal temperature is around 20 °C
- The wind can't be stronger than 20 km/h (5,6 m/s)
- Maximum precipitation is fog drizzle or individual raindrops
- If the weather conditions change significantly during the observation, you stop the observation and carry it out another day.

Observers work in pairs – one is observing, the other taking notes (a mark for each insect). They switch every 5 minutes or so.

The observation lasts for about 30 minutes.

Equipment:

- Basic equipment – headlamp/torch, paper, pencil
- thermometer
- anemometer

Description:

1. Pairs take their places and mark down every insect, which lands on the surface (one person is watching, the other marking). They switch every few minutes. The observation lasts for about 30 minutes.
2. After the observation the weather conditions are noted (the amount of clouds, moon, wind, temperature, precipitation).
3. Reporting the results.
4. Comparing the number of insects by different types of lamps.

Conclusion in the form of a discussion

- Why do insects land on illuminated surface? Which colour (bluish-white, yellowish-white, etc) attracts them most?
- How does this affect ecosystems? What does this mean for humans?
- General discussion on illumination

Activity 6

Observation of the activities of insects by lamps with different spectrums

Location:

A building (can be school or any other building)

Factors for choosing the observed location:

- As bright illumination as possible
- The smallest number of other visible lamps, besides the ones illuminating this surface
- Flat and unbroken surface – without windows, ledges, etc.
- Sheltered from the prevailing wind, if possible
- The side of the building which is exposed to the sun during the day – it retains heat longer.
- Facing a variety of habitats (ideally a forest) is an advantage
- The size of the observed surface depends on the reach of a strong lamp

Time of observation:

- Mid May to mid September
- For about 30 minutes
- Observation begins at nautical dusk - about half an hour after the sun is completely below the horizon.

Minimal weather requirements:

- The air temperature mustn't be below 10 °C, ideal temperature is around 20 °C
- The wind can't be stronger than 20 km/h (5,6 m/s)
- Maximum precipitation is fog drizzle or individual raindrops
- If the weather conditions change significantly during the observation, you stop the observation and carry it out another day.

Observers work in pairs – one is observing, the other taking notes (a mark for each insect). They switch every 5 minutes or so.

The observation lasts for about 30 minutes.

Equipment:

- Two spiral energy saving lamps (with power equivalent to 120 W): one regular lamp (with UV, colour temperature of 4200 K or more), the other adapted for greenhouses (with less UV, around 3000 K). The third lamp can be used, this one with yellow light (2500 K), and it is placed on the third wall. Red light can also be used. When choosing the lamps, it is very important that they all have the same power.

  Yellow lamps do not radiate in UV spectrum and therefore attract a much smaller amount of insects. The red light is almost invisible to insects.
- stands for lamps
- Basic equipment – headlamp, paper, pencil
- thermometer
- anemometer

Description:

1. Preparation: Put two or three lamps on stands and place them 50 to 100 cm from the wall and a few meters apart.
   - Determine the size of the observed surface on the facade – this depends on how far the strong enough light reaches
2. Pairs take their places and mark down every insect, whish lands on the surface (one person is watching, the other marking). They switch their roles every few minutes. The observation lasts for about 30 minutes and is carried out simultaneously by all lamps.
3. After the observation the weather conditions are noted (the amount of clouds, moon, wind, temperature, precipitation).
4. Reporting the results.
5. Comparing the number of insects by different types of lamps.

Conclusion in the form of a discussion

- Why do insects land on illuminated surface?
- Why does one lamp attract fewer insects than the other(s)?
- How does this affect ecosystems? What does this mean for the stability of the ecosystems? What does this mean for humans?
- General discussion on illumination

Activity 7

Observation of the activities of insects in tents for attracting moths with different types of lamps

Location:

Dirt road in, or close to, a forest

Time of observation:

- Mid May to mid September
- Observation begins at nautical dusk - about half an hour after the sun is completely below the horizon.
- For about 60 minutes (can be less)

Minimal weather requirements:

- The air temperature mustn't be below 10 °C, ideal temperature is around 20 °C
- The wind can't be stronger than 20 km/h (5,6 m/s)
- Maximum precipitation is fog drizzle or individual raindrops
- If the weather conditions change significantly during the observation, you stop the observation and carry it out another day.

Observers work in pairs – one is observing, the other taking notes (a mark for each insect). They switch every 5 minutes or so.

The observation lasts for about 60 minutes.

Equipment:

- Two identical tents, made specifically for nocturnal insect observation. Each tent has a different lamp with power equivalent to 120 W: one regular lamp (with UV), the other adapted for greenhouses (with less UV, its colour is a bit pinkish).
- Basic equipment – headlamp, paper, pencil
- thermometer
- anemometer

Description:

1. Day-time preparation: Find a suitable dirt road in a forest or on its edge. Both tents are set up about 100 meters apart.

2. We light the lamps approximately 30 minutes after the sunset. Pairs take their places by the tents and mark down every insect, whish lands on the tent (one person is watching, the other marking). They switch every few minutes. The observation lasts for about 60 minutes and is carried out simultaneously by both tents.
3. After the observation the weather conditions are noted (the amount of clouds, moon, wind, temperature, precipitation).
4. Reporting the results.
5. Comparing the number of insects by different types of lamps.

Conclusion in the form of a discussion

- Why do insects land on illuminated tents?
- Why does one lamp attract fewer insects than the other? Which part of the spectrum attracts them most?
- Is this part of the spectrum harmful for humans?
- How does this affect ecosystems? What does this mean for the stability of the ecosystems? What does this mean for humans?
- General discussion on illumination

Warning: it is suggested you do not make the tents by yourselves; installation and usage of electrical elements requires careful production.

In Slovenia the cost of such tents and all the needed equipment is between €300 and €350

Activities 8 and 9

Effect of light pollution on bats

Barbara Bolta Skaberne, Project Life+ Life at Night

Maja Zagmajster, University of Ljubljana, Biotechnical Faculty, Department of Biology

Slovenian Association for Bat Research and Conservation

Bats

Bats are amongst most endangered mammals. In Slovenia many bats find summer shelters in churches. Groups of mothers take care of their offspring in the cover of church attics and towers. Research shows that the illumination of a church and of the entry gaps delays the time of bats' flying out, which means that they start hunting later. This can mean they miss the dusk when the insects, their prey, are most active. This results in less food for female bats and consequently for their offspring, who are dependent on milk in their first few days. A result of this can be the fact that the offspring matures and starts hunting later. Their feeding season is shortened and they gather less energy reserve for the winter, which reduces their chances in making it through their first winter. Another factor is that the illumination decreases the number of insects which additionally affects the amount of food for bats. The bats also try to avoid illuminated areas in their flights to feeding areas, which causes them to use up more energy.

To avoid students' impatience it is suggested that you arrive on the location at about sunset.

Activities described below:

8. Observation of bats flying out of the church
9. Observation of differences in activities of bats flying around different types of street-lights

Preparation for the activities

All activities have to be well prepared to get the expected results. It is suggested that you prepare workshops with the help of a bat expert.

Activity 8

Observation of bats flying out

Location: a local church, or another building, which is occupied by bats.

Observers work in pairs – one is observing, the other taking notes (a mark for each bat flying out). They switch every 5 minutes or so.

If there are more entry gaps for bats, one or more pairs are watching each. The observation of all gaps is carried out simultaneously.

Time of observation:

- Mid May to mid September
- The beginning of the observation is sunset.
- We try to observe for at least 30 to 60 minutes. At this time some animals might already be returning.
- Keep track of flying in and flying out separately. Experts observe for 15 minutes after the last bat has flown out – this was how they find out the total number of bats living in this attic. The whole observation ends within two hours.

Minimal weather requirements:

- The air temperature mustn't be below 10 °C, ideal temperature is around 20 °C
- The wind can't be stronger than 20 km/h (5,6 m/s)
- Maximum precipitation is fog drizzle or individual raindrops
- If the weather conditions change significantly during the observation, you stop the observation and carry it out another day.

General instructions:

- Each observation is carried out if the minimal weather requirements are met: the air temperature mustn't be below 10 °C at the beginning of the observation; there should be no precipitation.
- Observation begins once the sun is completely below the horizon.

Equipment:

- Basic equipment: headlamp, halogen handheld spotlight, evidence sheet, pencil
- Ultrasound detector (not obligatory)
- binoculars
- thermometer

Taking notes – evidence sheet:

- Time that the first bat flies out (even if it goes right back in)
- Professional approach: noting the number of flying-out bats in 15 second intervals, starting with the time of the sunset. If needed, the interval can be 1 minute instead.
- In the table on the evidence sheet mark down every bat flying out and every one flying back in
- The temperature and other environment (cloudiness, wind, moon)

    a) At the time of the sunset,

    b) At the time the first bat flies out

    c) At the end of the observation

Description:

1. Find a place inhabited by bats.
2. Describe the illumination of the surrounding. (Road, playing filed, facades of the nearby houses, dark forest, etc.)
3. In daylight locate the openings, through which the bats might be flying out.
4. Make a sketch of the church/building and mark on it the possible entrances for bats flying out.
5. At sunset the group takes their places around the building and watches for bats flying out.
6. Observation is in pairs (one is observing, the other taking notes). All pairs observe at the same time.
7. The animals may not be using all the entrances you found during the day or are using some you didn't notice. On the sketch mark the active entrances.
8. Watch whether the active entrances are illuminated or not.
9. What direction are bats flying in? What is in this direction; a forest, a meadow, etc?. This is their feeding habitat.
10. Is the way to their feeding habitat illuminated or not?
11. Do bats take the illuminated corridors or the dark ones?
12. If there are illuminated and dark entrances, compare the number of bats flying out at differently illuminated entrances.
13. Reporting about the results and comparing them.

Conclusion in the form of a discussion

- Why do bats go out hunting at this time? (link to observation of bats at lamps)
- What happens if the entrances are illuminated alongside the rest of the building?
- How does this affect ecosystems? What does this mean for humans?
- General discussion on illumination

Bat box: We can observe bats flying in and out of bat boxes

Different species of bats find shelter in bat boxes than in attics.

- Species in bat boxes: common noctule bat (Nyctalus noctula), lesser noctule (Nyctalus leisleri), Bechstein's bat (Myotis bechsteinii), bats of pipistrelle genus (Pipistrellus), and probably parti-coloured bat or rearmouse (Vespertilio murinus), serotine bat (Eptesicus serotinus) and barbastelle (Barbastella barbastellus).
- Species in churches: lesser horseshoe bat (Rhinolophus hipposideros), Geoffroy's bat (Myotis emarginatus) and greater mouse-eared bat (Myotis myotis)

Activity 9

Observation of differences in bat behaviour in the vicinity of different types of street-lights

Location: different types of outdoor lamps (with white, yellowish light, et.); street-lights, facade lights, etc.

Observers work in pairs – one is observing, the other taking notes (a mark for each bat). They switch every 5 minutes or so.

There can be multiple pairs at each lamp.

All the observers work simultaneously.

Time of observation:

- Mid May to mid September
- Observation begins at sunset.
- We try to observe for at least 30 to 60 minutes.

General instructions:

- Each observation is carried out if the minimal weather requirements are met: the air temperature mustn't be below 10°C at the beginning of the observation; there should be no precipitation.
- The beginning of the observation occurs once the sun is completely below the horizon.

Description:

1. Preparation ahead of time: Find two different lamps, one with white, and the other with yellowish light. If there are more lamps, different pairs may observe all of them.
2. Describe the surroundings (the vicinity of a forest, meadow, in the middle of a village, in a city, etc.). Make a sketch of the location and the surroundings.
3. Pairs simultaneously take notes on the activities of each bat (even if more pairs take a note on the same bat approaching).
4. Reporting about the results.

Conclusion in the form of a discussion

- Why do bats fly to lamps?
- Why do bats generally avoid lamps?
- Why does illumination have a negative effect on long-term bats preservation?
- How does this affect ecosystems? What does this mean for humans?
- General discussion on illumination