Title	An instrument capturing horseflies by solar panels
Institution	Environmental Optics Laboratory, Department of Biological Physics, Physical Institute, Faculty of Natural Sciences, Eötvös Loránd University, Budapest
Authors	Gabor Horvath, Andras Barta, Gyorgy Kriska
Topic	A new horsefly trap based on reflected linearly polarized light and electricity produced by photovoltaics
Keywords	horsefly, tabanid fly, insect trap, solar panel, photovoltaics, rotating wire, linearly polarized light, polarotaxis

The concept

Horseflies (Diptera: Tabanidae) can cause severe problems for humans and livestock because of the continuous annoyance performed and the diseases vectored by the blood-sucking females. Therefore, effective horsefly traps are in large demand, especially for stock-breeders. To catch horseflies, several kinds of traps have been developed, many of them attracting these insects visually with the aid of a black ball. The recently discovered positive polarotaxis (attraction to horizontally polarized light) in several horsefly species can be used to design traps that capture female and male horseflies. The concept of our new horsefly trap is based on two novel principles: (1) The visual target of the trap is a horizontal solar panel (photovoltaics) attracting polarotactic horseflies by means of the highly and horizontally polarized light reflected from the photovoltaic surface. (2) The horseflies trying to touch or land on the photovoltaic trap surface are perished by the mechanical hit of a wire rotated quickly with an electromotor supplied by the photovoltaics-produced electricity. Thus, the photovoltaics is bifunctional: its horizontally polarized reflected light signal attracts water-seeking, polarotactic horseflies, and it produces the electricity necessary to rotate the wire. The effectiveness of this new horsefly trap was demonstrated in field experiments [Miklós Blahó, Ádám Egri, András Barta, Györgyi Antoni, Gábor Horváth (2012) How can horseflies be captured by solar panels? A new concept of horsefly traps using light polarization and electricity produced by photovoltaics. *Veterinary Parasitology* (in press) http://dx.doi.org/10.1016/j.vetpar.2012.04.016].

The need

Horseflies (Diptera: Tabanidae) can cause severe problems for humans and animals because of the diseases vectored by the blood-sucking females. Livestock, especially cattle and horses can be so strongly annoyed by the continuous attacks of blood-sucking horseflies that they cannot graze enough, and consequently their meat and milk production is drastically (e.g. 20-30%) reduced. Furthermore, horsefly bites cause visible scars on the skin of host animals. The bigger the scarless area of cattle hides, for example, the higher their value. As a consequence, the numerous bites of blood-sucking female horseflies can drastically lower the value of cattle bred for hide. Therefore, effective horsefly traps are in large demand, especially for stock-breeders.

The solution

Our new horsefly trap is composed of two horizontal solar panels fixed to the top of an aluminium house. At the center of the horizontal square surface of the trap the vertical axis of rotation of an electromotor gets through an aluminium band (1 cm × 2 cm × 60 cm). To the cylindrical (diameter = 2 cm, height = 1 cm) aluminium head of this rotation axis a thin (thickness = 0.5 mm), 60 cm long metal wire is fixed in such a way that the wire can rotate horizontally around its center parallel to and 3 cm above the photovoltaic trap surface. The aluminium band between the two photovoltaics and their aluminium frames are sprayed by a black paint. Thus, the whole horizontal surface of the trap is shiny black and reflects highly (i.e. with high degrees of polarization) and horizontally polarized light to attract polarotactic horseflies. The electromotor is supplied through a controlling electronics by the direct current produced by the two solar panels. The construction of the trap was made in compliance with the various sorts of environmental effects (e.g. angle of sunshine, resist of wind, and precipitation). The trap can be easily transported, as it is smaller than 1/8 m^3, and lighter than 10 kg. The trap can capture tabanid flies by nearly 90% efficiency from a distance of a few hundreds m. The photovoltaic surface must be cleaned up by warm water or methylated spirit at least one times weekly. We showed [Gábor Horváth, Miklós Blahó, Ádám Egri, György Kriska, István Seres, Bruce Robertson (2010) Reducing the maladaptive attractiveness of solar panels to polarotactic insects. *Conservation Biology* 24: 1644-1653 + electronic supplement] that strongly polarizing shiny black surfaces with an appropriate white frame and grid lose their attractiveness to polarotactic insects, including horseflies.

State-of-the-Art

Historically, traps based on flight interception principles and attraction to large black targets have been routinely used to capture horseflies. Blue-black cloth traps, such as the Nzi trap, for example, which rely on different attraction principles, are also frequently used for trapping horseflies. A common feature of many horsefly traps is that they are composed of a visual target – most frequently a black sphere – suspended underneath a tent-like canopy. The function of the visual target is to attract horseflies from a remote distance by means of optical cues (intensity and colour of target-reflected light, shape and motion of the target). When the attracted female horseflies land on the target and experience that a potential blood meal is not available, a proportion of them fly upward into the funnel-like end of the canopy, where they are trapped by a glass or plastic container. These traps capture almost exclusively female horseflies that look for host animals to suck their blood.

Beyond the State-of-the-Art

We have showed [Gábor Horváth, József Majer, Loránd Horváth, Ildikó Szivák, György Kriska (2008) Ventral polarization vision in horseflies: horseflies and deerflies (Diptera: Tabanidae) are attracted to horizontally polarized light. *Naturwissenschaften* 95: 1093-1100] that male and female horseflies are attracted to horizontally polarized light, just like many other aquatic insect species. The reason for this adaptive behaviour is that horseflies lay their eggs onto marsh plants near freshwater bodies or mud, thus they have to find water, what is performed by means of the horizontal polarization of light reflected from the water surface. We suggested that this positive polarotactic behaviour in horseflies could be used to develop new horsefly traps.

Our concept of such a new trap is based on two novel principles: (1) In this trap the new visual target is a horizontal solar panel (photovoltaics) that attracts polarotactic horseflies by means of the highly and horizontally polarized light reflected from the photovoltaic surface. (2) The horseflies trying to touch or land on the photovoltaics are perished by the mechanical hit of a wire rotated quickly with an electromotor supplied by the photovoltaics-produced electricity. The effectiveness of this new horsefly trap was demonstrated in field experiments [Miklós Blahó, Ádám Egri, András Barta, Györgyi Antoni,

Gábor Horváth (2012) How can horseflies be captured by solar panels? A new concept of horsefly traps using light polarization and electricity produced by photovoltaics. *Veterinary Parasitology* (in press) http://dx.doi.org/10.1016/j.vetpar.2012.04.016]. Using imaging polarimetry, we measured the reflection-polarization characteristics of the photovoltaic trap surface showing the optical reason for the polarotactic attractiveness of solar panels to horseflies.

Why now?

- **Discovery of polarotaxis in horseflies**: The biological basis of our new horsefly trap is that male and female horseflies are strongly attracted to horizontally polarized light. This behaviour is called the positive polarotaxis and has been discovered in 2008 [Gábor Horváth, József Majer, Loránd Horváth, Ildikó Szivák, György Kriska (2008) Ventral polarization vision in horseflies: horseflies and deerflies (Diptera: Tabanidae) are attracted to horizontally polarized light. *Naturwissenschaften* 95: 1093-1100]. Only recently was shown that the higher the degree of polarization of reflected light, the more attractive is the linearly polarized light that stimulates the ventral eye region of horseflies [Ádám Egri, Miklós Blahó, András Sándor, György Kriska, Mónika Gyurkovszky, Róbert Farkas, Gábor Horváth (2012) New kind of polarotaxis governed by degree of polarization: attraction of tabanid flies to differently polarizing host animals and water surfaces. *Naturwissenschaften* 99: 407-416 + electronic supplement]. Prior to these discoveries, it was not known that horseflies can be lured to the highly and horizontally polarized light reflected from shiny black surfaces.
- **Effective and inexpensive photovoltaics**: The physical basis of our new horsefly trap is that the smooth, black surface of horizontal photovoltaic solar panels reflects horizontally polarized light with high degrees of linear polarization. To attract horseflies, the surface area of such a horizontal photovoltaics should be large enough (1-2 m^2). The appropriately great photovoltaic surface area is also necessary to produce enough electricity providing the electromotor which can rotate the wire with great enough angular velocity to hit and perish the horseflies attracted to the horizontally polarizing photovoltaic surface. A few years ago photovoltaics were too expensive and not enough effective. Thus, a too large and expensive photovoltaic surface would have been needed for a horsefly trap based on solar panels. The current multicrystallic photovoltaics are efficient enough, and their price is low enough to use them in insect traps. Such photovoltaics are nowadays already available in the market for medium prices, which is one of the prerequisites of the production of competitive photovoltaic-based horsefly traps.

R&D expertise

- **Mechanical engineering**: The design of the trap requires some fine-mechanical engineering knowledge, because the different parts of the instrument should be adjusted and fixed in such a way that they are capable of enduring the inevitable mechanical stresses during the functioning in the field. Furthermore, the instrument has to be weather-proof, especially water-proof.
- **Electronic engineering**: The control electronics (including its firmware) is custom-built, and has to be produced during the development process.
- **Standard hardware knowledge**: The electronic parts of the trap should have standard interfaces to be easily connectable to each other.
- **Physical knowledge on light polarization and biophysical knowledge on insect polarotaxis**: The polarotaxis of certain insects requires polarized light with certain properties. The trap should be designed in a way that it reflects the light with the demanded polarization characteristics.

Beneficiaries

- **Estrato Ltd., Budapest** has the technical knowledge and experience in the development of polarization insect traps. This firm participated in the development of a passive sticky polarization horsefly trap, furthermore designed and built the version 1.0 of the photovoltaics-based rotating-wire polarization horsefly trap that was successfully tested in Szokolya, Hungary [Miklós Blahó, Ádám Egri, András Barta, Györgyi Antoni, Gábor Horváth (2012) How can horseflies be captured by solar panels? A new concept of horsefly traps using light polarization and electricity produced by photovoltaics. *Veterinary Parasitology* (in press) http://dx.doi.org/10.1016/j.vetpar.2012.04.016]. The scientific background and engineering of the members of the Estrato Ltd. guarantees that the company can successfully participate in the scientific part of the project as well.
- **Environmental Optics Laboratory (Department of Biological Physics, Physical Institute, Eötvös University, Budapest)** owns knowledge on light polarization in nature, insect polarization vision, and also has good experiences in leading field experiments with polarotactic insects [Gábor Horváth, Dezső Varjú (2004) *Polarized Light in Animal Vision – Polarization Patterns in Nature*. Springer-Verlag, Heidelberg - Berlin - New York, p. 447, ISBN 3-540-40457-0].

Impact

- **Estrato Ltd.** is interested both in the producing and selling of the developed photovoltaics-based rotating-wire horsefly trap.
- **Environmental Optics Laboratory (Department of Biological Physics, Physical Institute, Eötvös University**) is interested in performing researches on insect polarotaxis with the use of the developed trap.

EU priority

For a successful research and development project we need to gather the best experts in the fields of polarimetry, insect vision, engineering, development of scientific instruments. This justifies the demand to involve the above-mentioned consortium partners from the European Union, especially from the southern contries where horseflies cause severe problems for livestock, in order to achieve successfully the planned research and development during the proposed project.