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Production of Waves Mechanical Attractive to Mosquitoes: Design and Optimization of a System of Piegeage Electromecanique

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ABSTRACT

This paper presents the design of an electromechanical mosquito-trapping system based on the generation of mechanical/acoustic waves. The study assumed that the flight-tone-related acoustic signals can be detected by the mosquito antennal auditory system and incorporated into a trap architecture. The source research focuses on common vector mosquitoes, has 300-1000 Hz working range, and investigations conducted in Kinshasa. The proposed prototype handsets year Arduino UNO, signal generation/control, an amplifier, a loudspeaker, a capture chamber and, in a multimodal setting, temperature, CO_2 and airflow modules. The source document reports year illustrative experimental table using 50 mosquitoes per condition, with capture rates of 10% without wave emission, 16% at 200 Hz, 28% at 300 Hz, 40% at 400 Hz, and 32% at 500 Hz and 18% at 600 Hz. These values are retained as source data and are explicitly presented as requiring experimental validation. Scientific literature confirms the role of Johnston's organ in mosquito hearing and demonstrates strong frequency selectivity and harmonic interactions during courtship. The paper proposes a reproducible experimental methodology, the vibration equations, an Arduino-based functional architecture and optimization paths.

KEYWORDS: *mosquitoes; mechanical waves; Johnston's organ; acoustics; Arduino UNO; transducer; trapping; frequency.*

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1. INTRODUCTION

Mosquitoes are a group of insects of medical importance majeure. The control vector is based on several families of interventions and the world Health Organization recommends an integrated management-based interventions tailored to the context and on decisions informed by data.

The memory to the origin of this article is as a problem of the possibility of producing artificial mechanical waves that can attract mosquitoes and improve their capture. He holds an analytic approach, quantitative, comparative and experimental, with a delineation of thematic, centered on the frequencies from 300 to 1000 Hz and a study area to Kinshasa.

Modern literature confirms that hearing plays an important role in the sexual communication of mosquitoes. The flight produces an acoustic signal whose fundamental frequency depends on the species and sex. In Aedes aegypti, experiments have shown interactions harmonics between the tones of the flight of males and females.

The objective of this article is therefore to transform the contents of the memory in a scientific contribution is structured around four axes : (i) the biological basis of the hearing; (ii) physical modeling and electromechanical; (iii) the architecture and experimental protocol; (iv) data analysis and optimization of the prototype.

2. BIOLOGICAL FOUNDATIONS AND ACOUSTIC

2.1. Perception of sounds and body Johnston

The organ of Johnston is located at the base of the antenna, in the pedicel. It is the main device mechano-sensory involved in the detection of movements of the antennal induced by the variations

of the acoustic field. The work of synthesis describe an organization with a set ofscolopidies connected mechanically to the antenna.

The memory describes this structure as a receiver specialized vibration and stresses its role in the detection of the beating of wings. It also reports beaches indicative of frequencies for males and females; these values, however, must be interpreted as dependent on the species and biological conditions.

2.2. Interaction of acoustic

Gibson and Russell have shown that mosquitoes can change their flight frequency in response to those of a partner. Cator and his colleagues then demonstrated in Aedes aegypti, a harmonic convergence involving, in particular, a common component to 1200 Hz, while the physiological recordings of the organ of Johnston showed a sensitivity of up to 2000 Hz in the conditions of the study.

These results justify an experimental approach rather than a choice, a priori, of a frequency that is universal. The memory uses 300-1000 Hz as the range of work; the extension to other frequencies may be a later step.

2.2.1. Acoustic Emission by mosquitoes

Sounds are mechanical waves longitudinal propagating in air are shown in figure 2.1.

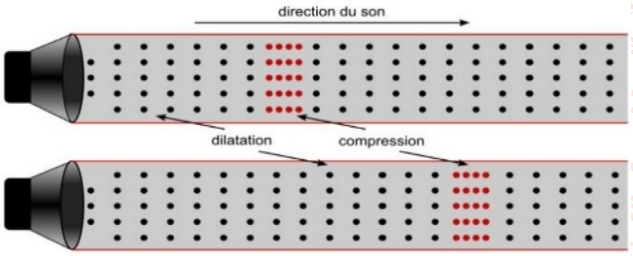


Fig. 2.1 : Illustration of mechanical waves longitudinal

We said earlier that mosquitoes can collect some acoustic vibrations with their antennae. The frequencies associated with the beating of the wings may vary depending on the species, sex, age, and environmental conditions.

The beating of the wings generate acoustic vibrations on the beaches frequency usually observed the following :

- female : 350 to 600 Hz;
- males : 500 to 900 Hz.

These frequencies vary in different species. It is noteworthy that the males emit a frequency slightly higher than the females.

Mosquitoes perceive the vibrations through a special organ located on the head, called the organ of Johnston.

2.3. The organ Of Johnston And The Detection Of Vibration

2.3.1. Sexual Communication

Males generally form swarms at dusk or dawn over visual cues to attract females during the mating.

The latter follow the trajectories oscillatory which a buzzing noise characteristic, the females enter the swarm to mate with males that would have emitted the wavelength-to-frequency characteristic.

In fact, the male detects the theft of the female, the frequencies of the two individuals synchronize the meeting becomes possible.

2.3.2. Harmonic resonance

Mosquitoes adjust their frequencies to beat in order to obtain a harmony acoustic promote the coupling.

2.3.3. Identification of mechanical waves attractive

1° natural Sources

The waves are attractive may come :

a) of females in flight;
b) the male in flight;
c) the swarms of reproduction of mosquitoes.

By definition, the swarms are collections of several mosquito flying together in a limited space. This phenomenon is observed mainly in males, and plays an essential role in reproduction.

2.3.4. Frequency attractive

Studies show that some of the beaches frequency attract preferentially:

- for males: the frequencies close to the beating of the wings of the females;
- for the females: the frequencies emitted by the males or swarms.

By studying the variations of the spectra or by analyzing the frequencies, we can identify:

a) the fundamental frequency;
b) the harmonics;
c) the temporal variations.

3. Physical modeling

3.1. Periodic wave

For a sinusoidal signal, the period T and frequency f are related by:

$$T = 1/f \qquad (3.1)$$

The wavelength λ, the speed v and the frequency f check:

$$v = \lambda f \qquad (3.2)$$

In the air, the transducer converts an electrical signal into mechanical movement of its membrane, and in the variation of sound pressure. For the study of the prototype, the frequency of the control signal is the variable of adjustment main.

3.2. Vibrational template

A simplified model with one degree of freedom can represent the mechanical system equivalent by a mass m, damping c, and stiffness k. Under excitation harmonic:

$$m\,x(t) + c\,x(t) + k\,x(t) = F_0 \sin(\omega t) \quad (3.3)$$

with $\omega = 2\pi f$. The natural frequency of unamortized of the model is:

$$f_n = (1/2\pi)\,\sqrt{(k/m)} \quad (3.4)$$

The frequency response depends on the ratio between the excitation frequency and the natural frequency, and damping. This formulation allows one to distinguish between the frequency programmed electrical to the mechanical response of real transducer.

3.3. Design of prototype electromechanical

The memory offers a modular architecture consisting of a signal generator, an amplifier, a driver and a capture chamber. The energy optimization is considering the issuance intermittent, a transducer, low power consumption, standby, and, eventually, a solar power supply.

Chaîne fonctionnelle du prototype de piégeage électromécanique

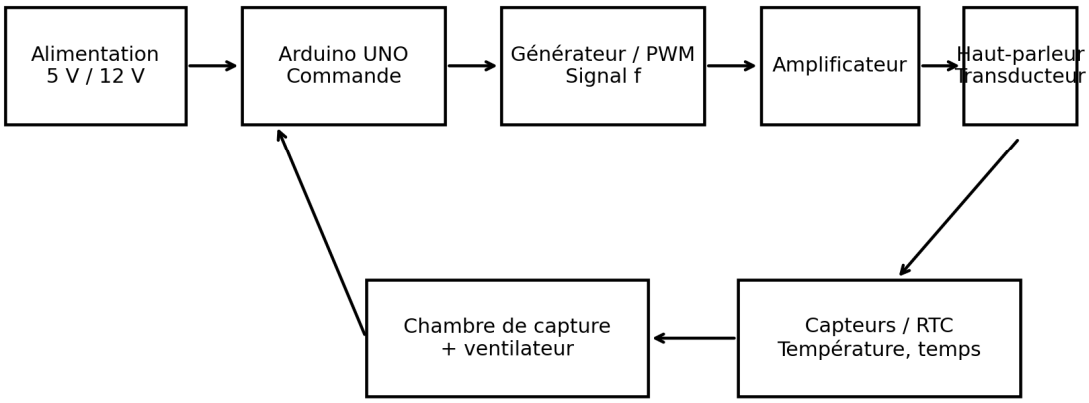


Figure 3.1. Block diagram proposed system Arduino generation and capture

In an implementation of the Arduino UNO, the card should not be fed directly to a power speaker. It provides the signal of command; the amplifier provides the power adaptation. The actuator-auxiliary (fan, solenoid valve, heater) must be ordered with power stages adapted, with common ground and electrical protections appropriate.

3.3.1. Architecture multimodal

The memory is considering the association of the mechanical signal with the carbon dioxide, a gentle heat, humidity, light controlled and attractive odorant. It also offers a conical inlet, a fan, low speed, and a compartment for collecting removable.

Scientific interest in architecture multimodal is to be able to compare the effect of the wave only with the combinations controlled. A factorial design is preferable to a comparison that is not controlled multiple configurations.

3.4. Experimental methodology

The proposed protocol (figure 3.2) preserves the methodological principles of memory: experimental comparative, control variables, and comparison with a control without issuing mechanics. Factors to monitor include the species, the gender, the number of individuals, approximate age, temperature, humidity, duration of exposure, the distance from the transducer and the acoustic level.

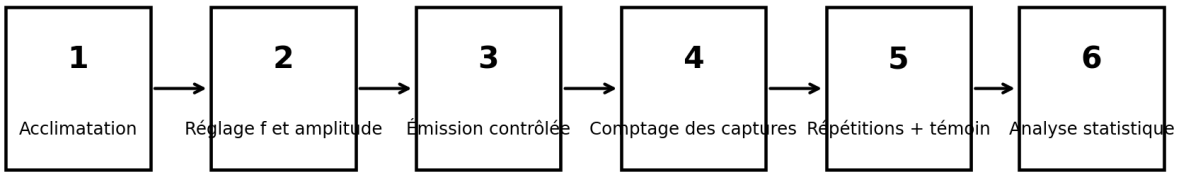


Figure 3.2. Diagram of the experimental protocol proposed

3.5. Variables

Independent Variable: primary frequency f. secondary Variables: amplitude/noise level, duration of emission, emission, continuous or intermittent, remote source–insects and possible combination with the CARBON/heat. The dependent Variable in main: the number and rate of catch.

The capture rate is defined by:

$$\eta c = (N\text{capturés} / N\text{introduits}) \times 100 \qquad (3.5)$$

To compare an experimental condition to a witness, we can use the relative increase:

$$A\text{rel} = [(\eta(c,\text{exp} - \eta(c,\text{cookie}) / \eta(c,\text{a witness}] \times 100 \qquad (3.6)$$

4. PRESENTATION, ANALYSIS, INTERPRETATION OF RESULTS AND DISCUSSION

Table 4.1 below gives the interpretation of 50 mosquitoes per condition, according to the influence of the frequency on the rate of capture. It is reproduced here without convert its values to results on the newly measured.

Table 4.1. Influence of the frequency on the rate of capture

Condition	N	the Catch	Rate (%)
Without wave	50	5	10
200 Hz	50	8	16
300 Hz	50	14	28
400 Hz	50	20	40
500 Hz	50	16	32
600 Hz	50	9	18

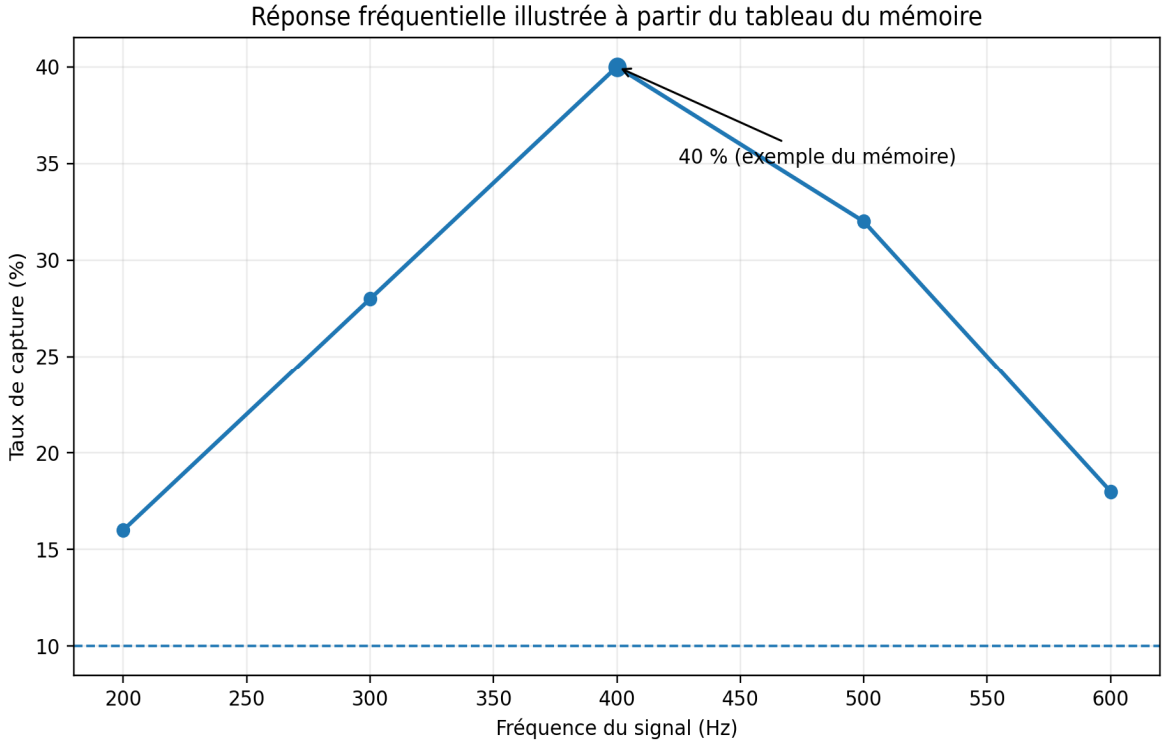


Figure 4.1: graphical Representation of the rate of capture of mosquitoes

In this series, the rate of capture is reduced from 10 % to witness 16 %, 28 %, 40 %, 32 % and 18 % for 200, 300, 400, 500, and 600 Hz, respectively. The maximum observed in this series is thus associated to 400 Hz. The absolute deviation between 400 Hz and the witness is 30 percentage points, and the relative increase compared to the control is 300% according to the equation (3.6). This last value should be interpreted with caution, since it is based on a single series of data reported and not on statistical analysis with repetitions.

The curve suggests a response area around 400-500 Hz, but it does not establish an optimal frequency universal. The literature shows that the signals of flight and the hearing sensitivity varies according to the species and sex, and that of the harmonic components can also be used.

4.1. Discussion

On the biological level, the hypothesis that use of the sounds of flight signal behavioral is compatible with the work on the acoustic communication of mosquitoes. However, attraction, approach and capture are three distinct phenomena. An acoustic response measured does not automatically guarantee an increase in the number of insects actually used in the trap.

On the technical side, the performance depends on the transducer, amplifier, sound level actually delivered to the position of the mosquitoes, the direction of the source, the geometry of the chamber and the ambient noise. A characterization of instrumental signal is therefore essential to make the tests repeatable.

The recent literature also describes a hearing highly selective and flexible in mosquitoes. This complexity increases the interest of a sweep frequency and amplitude control, rather than a fixed setting presented as universal.

4.2. Optimization and prospects

The optimization frequency can be achieved by automatic scanning around the frequencies of interest. The energy optimization can use a program intermittent. The optimization of mechanical door on the room of a cone, the positioning of the transducer, the suction compartment and the collection. The memory also recommends that the association with other attractive.

For a publication, complete experimental, future work should include: (1) several repetitions independent by condition; (2) randomization of the order of the frequencies; (3) measurement of the sound level at the point of exposure; (4) the taxonomic identification of the mosquitoes; and (5) distinguishing males/females; (6) statistical analysis adapted, for example, binomial model or mixed model if multiple series are available; and (7) validation in an enclosure or in a semi-open before the test field.

The approach is consistent with the principles of integrated vector management, with its focus on decisions based on the data and the adaptation of interventions to the local context.

5. CONCLUSION

This article presents a structured version and publishing of the design project of a trap, electro-mechanical, using mechanical waves. The biological basis is based on the auditory system antennal and body Johnston; the technical foundation is based on the generation, amplification, and transduction controlled from a signal. The memory provides a first set of data indicating a maximum of 40 % of the catch to 400 Hz in the conditions reported. This observation is a track optimization, and not proof of a frequency that is universally optimal.

The next step in science is to repeat the tests according to a protocol-controlled, to accurately measure the acoustic field and to separate the effects of the frequency, amplitude, and other stimuli. The integration of an Arduino UNO provides a platform that is accessible to automate the generation of signals, the cycles of the issuance and the command of the auxiliaries. The prototype will evolve to an experimental system for autonomous and assisted delivery.

THANKS

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REFERENCES

[1] Cator, L. J., Arthur, B. J., Harrington, L. C., & Hoy, R. R. (2009). Harmonic convergence in the love songs of the dengue vector mosquito. Science, 323(5917), 1077-1079. https://doi.org/10.1126/science.1166541;

[2] Gibson, G., Warren, B., & Russell, I. J. (2010). Humming in tune: Sex and species recognition by mosquitoes on the wing. Journal of the Association for Research in Otolaryngology, 11, 527-540. https://doi.org/10.1007/s10162-010-0243-2;

[3] Gibson, G., & Russell, I. J. (2006). Flying in tune: Sexual recognition in mosquitoes. Current Biology, 16(13), 1311-1316. https://doi.org/10.1016/j.cub.2006.05.053;

[4] Göpfert, M. C., & Robert, D. (2001). Active auditory mechanics in mosquitoes. Proceedings of the Royal Society B: Biological Sciences, 268(1476), 333-339. https://doi.org/10.1098/rspb.2000.1376

[5] Loh, Y. M., Su, M. P., Ellis, D. A., & Andrés, M. (2023). The auditory efferent system in mosquitoes. Frontiers in Cell and Developmental Biology, 11, 1123738. https://doi.org/10.3389/fcell.2023.1123738

[6] Service, M. W. (2012). Medical entomology for students (5th ed.). Cambridge University Press.

[7] World Health Organization. (2004). Global strategic framework for integrated vector management. World Health Organization.

[8] World Health Organization. (2012). Handbook for integrated vector management. World Health Organization.

[9] World Health Organization. (2026). Operational manual on larval source management: Control of Anopheles and Aedes mosquito vectors. World Health Organization.