Research Note

Attractancy of various waveform sounds in modulated intensities to male mosquitoes, *Culex quinquefasciatus*, in the field¹⁾

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When wingbeat sounds of female mosquitoes were mixed with the other sounds of female, male or different species, the attractancy of mixed sounds to males did not differ from that of the original female sounds (Ikeshoji, 1982). Frequency-modulated female sounds by 25 or 50 Hz could increase neither attractancy nor sterilization effect of a chemosterilant-treated sound trap, when they were tested to three species of mosquitoes in the lab. In the present work, we further investigated for the possibility of increasing the attractancy of sound by changing the waveform and modulating the intensity.

Sound 1 MQ(R) was the actually recorded

400-Hz wingbeat sound of a 4-day-old female of *Cx. quinquefasciatus* (Fig. 1). The following four 400-Hz sounds: 2 MQ(B), 3 MQ(N), 4 MQ(E) and 5 MQ(I), were synthesized in repeating one actual waveform of the recorded sound by a computer. The sinusoidal and sawtooth 400-Hz sounds, 6 and 7, were similarly composed by the computer. Sound 7 was in a sawtooth waveform, but the generated sound through a speaker was highly distorted due to its characteristics as shown in Fig. 1. All sounds were arranged in 5-sec durations with 5-sec intervals as shown in Fig. 2. These sounds were recorded in 3- or 5-min endless tapes and played with a small cassette tape-recorder, Sony WA-3000, to which a 9-cm diam., 8- Ω and 1-W speaker was connected. Whereas, sound 8 Sine G was emitted directly from a hand-made electrical generator. The speaker was enrolled with a clear polyethylene sheet to form a 30-cm long cylinder and the inside wall was sprayed with glue (Kinryu®) at both ends (Ikeshoji, 1986). Then, the sound trap was set on a 30-cm high tripod which stood on a 1×2 m black cloth spread at a ditch side in Bukit Tengah, Butterworth, Malaysia. Sound pressure levels of the emitted sounds varied little between 88 and 91 dB at the cylinder orifice, except sound 8 at 110 dB. One sound was emitted for 20 min from 19:53 o'clock in the evening. The eight different sounds were tested in a random order for 38 nights from July 8 to August 14, 1986. Males of *Culex quinquefasciatus* stuck on the wall were counted. Meanwhile, the size of male population in the test area was checked by taking a 5-min aerial net sample at 20:15 o'clock every night.

Attractancy of the sound was expressed with three different statistics: 1) average number of trapped males a night, 2) average of non-parametric ranks of the trapped numbers in all 38 day tests, and 3) average of ratios of the trapped numbers to the net-caught numbers. The results are shown in Table 1. The daily population was quite variable in the field during the experimental period and so was the number sound trapped. Sound 4 (hereafter, sound and sound source are used interchangeably) trapped 69.0 males a night which was significantly larger at 5% level than 22.8 males of sound

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Fig. 1 Waveforms and frequency spectrograms of the tested sounds generated by a cassette tape-recorder and analyzed at the orifice of a sound trap.

Refer Fig. 2 for the sound numbers.

Table 1 Attractancy of various waveform sounds in modulated intensity to male mosquitoes in the field.

Sound No. ¹⁾	No. of tests	No. of trapped (range)	Rank	No. of trapped/net catch
1	5	28.4 (5-54)	21.0	0.41
2	4	32.8 (23-39)	16.8	0.77
3	4	32.3 (18-55)	18.8	0.44
4	5	69.0 ^{a, b} (32-162)	8.7 ^{c, d}	2.74 ^{e, f}
5	4	29.5 (25-33)	19.0	0.64
6	5	22.8 ^a (4-49)	23.9 ^e	0.50 ^e
7	5	20.6 ^b (9-56)	26.5 ^d	0.45 ^f
8	6	29.2 (2-64)	20.4	0.42

¹⁾ Refer Figs. 1 and 2 for the sound numbers.

^{a-f} The means with the same letters a, b, e and f were significantly different at 5% level of *t*-test when numbers or ratios were log-transforms, whereas the means with c and d were so when the numbers were ranked.

Fig. 2 Various waveforms of the sounds tested in different intensity modulations.

6 and 20.6 males of sound 7, when the trapped numbers were log-transformed and the averages were *t*-tested. The differences between these sounds were also significant, when the numbers were ranked from 1 to 38, and when the ratios of the trapped numbers to the net-caught numbers were log-transformed. The differences among other sounds were, however, insignificant due to the large variation of the daily trapped numbers.

Since sound 3 was slightly better than

sounds 6 and 7, although statistically insignificant, it might be said that the wingbeat waveform sound is more attractive to males than the sinusoidal and sawtooth sounds. Sound 6 was the only pure sound with few harmonic components, whereas the other sounds, 1, 3 and 7 commonly had higher harmonics in strong intensities as shown in Fig. 1. In this connection, Wishart and Riordan (1959) have denied the importance of harmonics in mosquito attraction in the lab experiment. Then, the difference of waveforms only could explain the better attraction of sound 3.

Sound 4 was the most attractive sound, followed by sound 2. The common feature of these sounds was the 1-sec fading out vibration at the end of each pulse. This intensity modulation would be significant in male attraction, since it might mimic a remoting female to a chasing male. In this regard, however, Wishart *et al.* (1962) could not detect any difference of attractancy to *Aedes aegypti* males when the intensity and frequency (as Doppler effect) of the stimulating signal was modulated at a rate of the approaching or remoting female in the lab experiment.

In conclusion, the fading out of intensity at the end of each pulse of female waveform sound was more attractive to males than other types of sounds tested.

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摘 要

ネッタイイエカに対する各種
波形音の誘引野外実験

まず雌蚊の羽音の波形, 正弦波形, 鋸歯波形をコンピュータを使ってくりかえし, 400 Hz 5秒ごとの断続音を合成し, エンドレステープに録音した. この音の誘引性をマレーシア, バターワース市で, 群飛する雄蚊に対してテストした. その結果, 羽音合成音で各パルスの最後を減衰した断続音が最良であった. 雄蚊はこの減衰音を遠ざかる雌蚊と感知すると考えられる.