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Palmated Antlers of Moose May Serve as A Parabolic Reflector of Sounds

George A. Bubenik
University of Guelph

Peter G. Bubenik
Cleveland State University, p.bubenik@csuohio.edu

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SHORT COMMUNICATION

Palmated antlers of moose may serve as a parabolic reflector of sounds

George A. Bubenik · Peter G. Bubenik

Abstract It has been postulated that the excellent sense of hearing in moose is mostly due to: (1) the large surface of the external ear, (2) better stereophony due to the large distance between ears, (3) independently movable, extremely adjustable pinna, and (4) the amplification of sounds reflected by the palms of the antlers. The last factor, possible reflection of sounds into pinna by the palm of the antlers, was tested in this study on a large antler trophy of Alaskan moose. The reception of a standard tone, broadcast from the frontally placed speaker, was recorded by a sound level meter located in an artificial moose ear. Three locations of the ear, as positioned relative to the speaker, e.g., frontward, sideward, and backward, were tested. The weakest reception was recorded in the backward position of the ear. If the sound pressure measured in the frontward position was set as 100%, the sound pressure in the backward position was 79%. The strongest reception was recorded when the artificial ear was positioned toward the center of the antler palm. In this position, the sound pressure was 119% relative to the frontward position. These findings strongly indicate that the palm of moose antlers may serve as an effective, parabolic reflector which increases the acoustic pressure of the incoming sound.

Introduction

The moose, the largest cervid species, which can weigh over 700 kg, inhabits mostly boreal regions of northern Europe, Asia, and America (Bubenik 1998a). To locate suitable mates in the vast regions of the tundra, moose have developed keen senses of smell and hearing. Moose calling has often been recorded at distances of over 3 km, and some sounds produced by moose, such as hiccups are probably below the threshold of human perception (Bubenik 1998b). It has been reported that antlered bulls can locate the position of the cow with much greater accuracy than antlerless moose of both sexes (Bubenik 1987). It has been postulated that the capacity of antlered moose to locate sounds is fostered by four mechanisms: (1) the large external surface of the moose ear (the average surface of the pinna is around 430 cm^2, which compares with only 7 cm^2 in humans), (2) excellent stereophony (the distance between ears in moose is around 36 cm, in humans it is only 18 cm, (3) independently movable, extremely adjustable pinnae, movable in 360° around the ear base and 90° perpendicular to the body, and (4) the amplification of the incoming sound by the palms of the antlers which can serve as a parabolic acoustic reflector with focal points of 50 cm and more apart (Bubenik 1998b).

The last mechanism, the capacity of palmated antlers to serve as a parabolic acoustic reflector was first proposed by A. Bubenik. If his hypothesis is true, then the low frequency of moose sounds, which penetrate more easily through forested terrain, should be heard by moose at much farther distances than is possible for humans (Bubenik

1987). The presumed property of palmated antlers as an amplifier in sound perception was first tested in an early experiment of Bubenik, and the results were presented in 1988 in the movie "Avoir du Panache" by J. L. Frund and A. B. Bubenik. The possible amplification of acoustic pressure in moose was tested in a simple experiment in which a microphone was placed in the ear of a taxidermic bull head, first with and then without the antlers. An increase in sound pressure level was recorded when antlers were attached.

To test the effect of antlers on sound reception, we decided to repeat this study with an artificial ear mounted on the antler trophy and rotated in three different positions with respect to the speaker.

Fig. 2 Sound meter inserted into the artificial ear

Materials and methods

Trophy antlers of an Alaskan moose were placed on a large tripod and equipped with realistic artificial ears manufactured in the workshop of the NHK, a public television channel in Tokyo, Japan. The antlers weighed around 18 kg and had a maximal span of 138 cm. The ears were fixed close to the skull in the position where they are normally located in the bull moose (Fig. 1). The left ear was equipped with the sound level meter, InterTan Canada, model 33-2055 (Fig. 2). The microphone's end was extended by a plastic tube to fit deeper into the ear canal. The sound meter was attached to the ear by a rubber band and several strings. The sensitivity of the meter was adjusted to between 50 and 70 decibels (dB). The ear was utilized in three positions: frontward (directed toward the incoming sound), sideward (directed toward the center of the antler's palm), and backwards (aligned with the position of the neck). The meter was first exposed to a standard humming sound, which originated from the interference between the speaker and the cassette recorder. The sound tape was played on a stereo cassette recorder (Sony, Japan, model CF-610). The speaker was located approximately 10 m from the tripod, at the same height as the trophy. The intensity of the sound was adjusted to the sensitivity of the microphone. After conversion of the sound pressure level from decibel (dB) into the SI unit of Pascal ($P=N/m^2$), we compared the sound pressures measured for the different positions of the ear, using Student's *t*-test for data evaluation. The sound pressure recorded in the frontward position of the ear was taken as 100%.

Preliminary experiments were performed in the basement of a house, and then eight measurements for each ear position were performed outside, in the arboretum of the University of Guelph.

Fig. 1 Trophy antlers mounted on the tripod with the attached artificial moose ear positioned against the center of the antler's palm

Results

When the ear was positioned directly against the source of the sound (frontward), the average recorded sound pressure level was 59.5 dB±0.19 SE. When the ear was placed backwards, the average sound pressure level reached only 57.5 dB±0.19 SE. The highest average sound pressure level, 61.0 dB±0.0 SE was recorded when the ear was placed sideward, directed toward the center of the antler's palm. When the measurements were converted to Pascal ($P=N/m^2$), and the frontal position of the ear toward the speaker was taken as 100%, the backwards position achieved a relative sound pressure of only 79%, while the sideward position toward the antler palm had a relative pressure of 119%. Using Student's *t*-test, all of the pair-wise comparisons differ significantly ($P<0.001$).

Discussion

Among all cervids, only in the moose do females have a richer repertoire of vocalization than males (Bubenik 1998b). This indicates the importance of vocal communication in this species, whose individuals must find each other in the vast spaces of the tundra or taiga. Palmated antlers are a general feature in most male Alces, and therefore their utilization in communication would provide an extra advantage, especially to animals with large antlers. Our preliminary experiments indicate that smaller antlers are not as effective in sound amplification as larger ones (Bubenik G.—personal observation).

It can be argued that the sound used in our study (the standard humming tone) is very different from the original moose calling. We used recorded moose calls in preliminary testing, but we decided against it and used a low frequency tone of standard intensity instead. The reason for this was that the variation in individual segments of moose calls was too large to be reliably picked up in repeated recordings. Furthermore, the moose calls were described as vocal expressions of low frequencies which penetrate forested terrain more easily, than high frequency sounds (Lent 1974).

In our experiment, the acoustic pressure nearly doubled when the meter was moved from a backward position toward the palm of the antlers. Surprisingly, the acoustic pressure also increased by almost 20% when the meter was moved from directly facing the sound source to a sideward position facing the antlers. This strongly indicates that the palmated antlers of moose may serve as a parabolic reflector of sounds amplifying incoming sounds.

In conclusion, our experiment confirmed and expanded the findings of Bubenik (1987, 1998b) who suggested that the palms of moose antlers may amplify incoming sounds and so aid in moose communication.

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