COMMENT ON EXTREMELY LOW FREQUENCY RADIO EMISSIONS IN BAT CAVES

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After reading the article Extremely Low Frequency Radio Emissions in Bat Caves (Koemel, 1996) I felt compelled to write to highlight several problems and questions that this article raised in my mind. These center primarily around the methods used for the data observation and the conclusions that this article purports as well as why the article was not challenged more vigorously before publication.

DISCUSSION OF THE METHODS USED

In a scientific data collection process one of the objectives is to distinguish the data being collected from noise that is inherent in the system collecting the data. No efforts were really made in this article to establish the noise floor of the system being used. There are several simple experiments that could be performed to establish what signals are data and what is the noise level of the system. For instance, if the recording apparatus were operated in an electrically shielded room such as a metal screen room used for EMI and RFI testing, then a baseline could be established for the recording system.

To perhaps demonstrate the low frequency radio emissions of bats even better than the data presented in the article, a bat could be introduced into the screen room test. This would maximize the signal to noise ratio possible for this recording system and help further characterize the emissions that have been observed.

Another concern with the methods used is the process of tape recording the data logging sessions. Using a wide band receiver is certainly a good idea for this type of investigation. However, the signal seems to be bandwidth limited to the device hooked to the output of the receiver. Either 18kHz when the earphones are used, or by the tape recorder when it is used. High fidelity tape recorders could perhaps get to 15kHz or so, but most portable recorders that I have seen (and most likely used for the field work) would not have a bandwidth much beyond 5-6kHz. Nothing in the article discusses the type of recorder or tape that was being used even though they probably are the devices limiting system bandwidth. Again, a screen room test with and without the tape recorder would help establish what it might add to the system noise figure.

Even though the graphs presented in the article make up half the printed space, they represent a total of less than one half second of data. In some cases there is clear evidence of signal information, but in several cases I am not convinced that the signal presented is not a transient from an unknown source. A correlation study of many signals of the same suspected source would perhaps be in order, or an observer recording bat flights and correlating these to a longer-term signal recording might prove informative.

All these suggestions are not to say that I don't think bats emit low frequency radio emissions, in fact I think they probably do. My concern is that by making several more simple observations and presenting data in a different way the case for these emissions could be made much stronger.

DISCUSSION OF CONCLUSIONS

Which brings me to the other topic that I would like to discuss. The title of the article and all of the information presented concern low frequency radio emissions, then when Mr. Koemel reaches his conclusion section he makes four conclusions that I have a hard time relating to the rest of the article in any way. On top of that he fails to address the low frequency radio emissions from bats which I was led to believe was the point of the article in the first place.

First, concluding that bats can detect atmospheric weather conditions from inside a cave is a far stretch from the data presented. Granted, the apparatus used to collect data may be able to detect weather conditions and bats indeed may be able to detect weather conditions, but nowhere is the behavior of bats in different weather conditions discussed in this article except for this conclusion statement.

Second, bats may be affected by 60Hz ground return currents in caves. Again, this may very well be the case, but how does any of the body of this article support this conclusion? I have to repeat, nowhere is the behavior of bats under different conditions presented in this article.

Third, how is the use of the VLF emissions for predation and location of young arrived at by the author? Were the emissions that were observed always just before the bat captured an insect or in the presence of young bats? At best, I think that Mr. Koemel could conclude that bats emit VLF radio signals, but the purpose of these emissions I believe is still more speculation than conclusion and should be stated that way.

Fourth, concluding that bats can locate a cave entrance in the dark because they can orient themselves to the earth's magnetic field is again not supported in this article. I think that Mr. Koemel's observation that bats spiral in different directions in different hemispheres is very interesting and worth further investigation. However, water spirals down a drain in different directions in different hemispheres because of gravity, friction, and the rotation of the earth, not magnetic field. Maybe other forces are at work on bats too. The leap is then made to conclude that this magnetic orientation talent helps

bats with cave entrance location. I again didn't find any discussion of bat navigation in the article or how the ability of bats to locate entrances was observed by Mr. Koemel.

SUMMARY

There are two areas of improvement that I would like to suggest. First is the referee process for the *Journal of Caves and Karst Studies* and second is the methodology and conclusions presented by Mr. Koemel. It is my opinion that the referees that reviewed this article should have caught this article in the "quality" filter before it was published to maintain the high standards that the *Journal* is trying to achieve. With the appropriate presentation of the information that Mr. Koemel has collected I think there is a very fascinating conclusion lurking in the article. However, the conclusions that Mr. Koemel presented detract greatly from the message contained in the methods and results of the article.

REPLY TO COMMENT ON EXTREMELY LOW FREQUENCY RADIO EMISSIONS IN BAT CAVES

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First, I want to thank Mr. Withrow for having enough interest to read my paper and consider the observations. In essence, my paper says, "Please consider these things in your research."

Obviously, Withrow did not build a copy of my wideband radio receiver as fully described in Koemel and Callahan (1994). If he had, he would know its noise floor is at zero (dead silent). In 1983, I corresponded with W.R. Intosh (Mr. Computer) concerning this instrument. This instrument was thoroughly tested before 1994. The observed frequencies are well within the limits of the cassette tape recorders mentioned by Withrow.

I want bat researchers to introduce a bat into a Faraday cage (screen room) to study this phenomenon further. Bats might produce radio frequencies far above the observed frequencies. The Wright brothers were the first to fly, but they did not fly coast to coast, or break the sound barrier on their first flights!

The oscilloscope prints in this paper represent recordings containing many 2000 to 3500 Hz radio pulses from each of several caves. The figures are not graphs, but actual oscilloscope displays from a digital computer oscilloscope. They contain more information than can be printed in words in the same space. For example, figure 4 (Koemel, 1996) shows a decaying 2000 Hz pulse from an unknown source in a moonlit sky. All the signals from the earth were electrically shielded out. The 2000 Hz pulse is shown from 0-10 ms. The rest of the display shows background noise from 15-50 ms. Figure 5 shows radio emissions near the ceiling of Mason Bat Cave with no evidence of 60 Hz. This cave is very small with a very prolific bat population. This contrasts greatly with figure 7 which shows a strong 60 Hz emission near the ceiling of Lair Cave. Lair Cave is of similar size, but has a sparse diminishing bat population. Please compare the presence of 60 Hz in caves with diminished bat populations and diseases. Figure 8 shows a 2500 Hz pulse between 15 and 20 ms. The rest of the display shows background noise. Figure 9 shows a 2000 Hz pulse between 45 and 50 ms. The rest of the display shows background noise. Figure 1 shows static spikes from rain clouds near Mason Bat Cave. This shows the radio pulses produced by bats are different from atmospheric discharges. The observations made in the entrance to Carlsbad Cavern were made before and during the bat flight. The 2000 Hz pulses were not present before the bat flight.

Page 35, paragraph 7 (Koemel, 1996) contains the preliminary data about radio pulses produced by flying bats. Please do more research that relates to this data. I showed that different weather conditions produce different ELF radio spectra. These ELF signals can be observed inside the cave. Ask any bat researcher how he bats know when to fly or when not to fly out from the cave when atmospheric conditions inside the cave are very different from atmospheric conditions outside. Bat flights are totally unpredictable in relation to sunset or time. The conclusion will be obvious.

It is not gravity and friction that causes hurricanes to rotate counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere. Ben Franklin demonstrated that a flow of electrons will move air.

Let's search for a magnetic anomaly. Manta rays and honey bees use magnetic field lines as references when they return to their nest. Why not bats? If one moves a beehive three meters after some of the worker bees go out to forage, the honey bees follow an invisible, unscented reference while returning to the beehive. They return to the original hive site. They have difficulty finding the new hive site even though it is only 3 meters away and clearly visible with the scent of the queen bee inside.

COMBINED REFERENCES

Koemel, W. C. (1996) Extremely low frequency radio emissions in bat caves. *Journal of Cave and Karst Studies 58*(1): 35-37.

Koemel, W.C. & Callahan, P.S. (1994). Relationship of extremely low frequency radio emission from flying insects to semiochemical communications. *Annals of the Entomological Society of America 87*: 491-497.