Notes from the Panorama of Science

Rapid Relay of Sound Vibration Alarms: Headbanging Termites!

"For if the trumpet gives an uncertain sound, who shall prepare himself for the battle?" (1st Corinthians 14:8)

Headbanging termites are alarming, literally!

Termites dwell in moisture-regulated (and "air-conditioned") mounds much larger than their little (about a centimeter-long) bodies. When termite mounds are structurally breached and attacked by hungry predators (such as aardvarks or pangolins or ants), some termites (often called "workers," responsible for food acquisition) flee, while other termites (often called "soldiers," some of which serve as "sentinels") defend the colony's homestead, by rushing to perform emergency repairs or by rushing to counter-attack the invaders, perhaps by swarming upon and biting whomever the invading threat is. Those defensive sentinel-like termites, who "sound the alarm," communicate quickly.

> Kirchner explains that the African termite, *Macrotermes natalensis*, forms large colonies in subterranean mounds and operates on a caste system. The workers use the mound's maze of corridors to access the outside world to forage for food. As these outdoor excursions can take them over 10 m away from their colony, they are accompanied by another caste—the solider termites. In addition to protecting them, these soldiers will drum home warnings of an impending attack to the distant colony should a hungry aardvark appear. (Stead, 2013)

Communicating over long distances is difficult; for example, the sound of our voices can rarely be heard or understood further [sic, farther] away than 100 m. Yet, long before the invention of the telephone or e-mail, humans were successfully communicating over hundreds of kilometres. Take, for example, the Great Wall of China, where soldiers alerted each other of an impending attack using smoke signals. Although this remarkable ability to communicate over long distances is said to be unique to humans, Wolfgang Kirchner and PhD student Felix Hager, from the University of Bochum, Germany, found out that some species of termites have also mastered the skill. (quoting Kirchner and Hager, 2013, p. 3249)

This a quite an "alarming" report, by Nicola Stead (Stead, 2013), pardon the pun.

Yet this alarm—which may be transmitted several meters (if necessary) is not accomplished by one sentinel termite's loud broadcast; rather, the alarm is communicated throughout the mound's inside "gallery" chambers and tunnels (including the honeycombed subterranean chambers, tunnels, and fungus "gardens") of the mound by a relay of warning signals.

Thus, the signaling is drastically important when a mound-invasion crisis occurs. Some termites rush away in flight. Other termites rush toward the emergency site, to provide needed defensive actions.

As 1st Corinthians 14:8 illustrates, transmitted signals provide coded messages, intended to influence message recipients (see also Johnson, 2011). Like-

wise, animal populations employ diverse communication modes (Moon, 1962; Johnson 2020a, 2020b). This demands intelligent communication systems that are pre-programmed into all of the termites, so that the threatened termites can react purposefully to such suddenly hostile environments (Johnson, 2011).

As humans, we can relate to such environmental crisis situations. For ages humans have used a chain-like series of relay signals, to rapidly communicate danger (or distress) across long distances. The idea of relaying a warning by signal fires (relay beacons) appears in J.R.R. Tolkien's "Lord of the Rings" fiction.

However, in real-world history, Vikings used relay signal fires to communicate impending dangers—as illustrated in the "Saga of Håkon the Good," in Snorre Sturluson's classic Viking history *Heimskringla, or The Lives of the Norse Kings* (Monsen, 1990, Chapters 20–22, pp. 91–92).

But how do headbanging termites accomplish this warning behavior, and why?

Unlike the term "headbanging," used to describe repetitious head-jerking to bass guitar beat rhythms in heavy-metal rock music, headbanging termites literally bang their heads upon the "floor" (mound substrate), emitting pulsating sound and vibrational signals toward nearby nestmates (Choi, 2013; Stead, 2013).

The "why" is purposeful design, by the termites' Creator (the Lord Jesus Christ), Who programmed these small insects to actively communicate warnings unto one another—for their populational survival in this fallen world from predatory attacks (due to sin-cursed conditions on Earth, that Christ foreknew Adam's sin would trigger)—exhibiting the ongoing reality of Romans 5:12 and 8:20–22 (Gitt, 2007; Johnson, 2011).

Like other creatures of the world, big and small, headbanging termites (e.g., *Macrotermes natalensis*)—are cleverly constructed to communicate important messages (Moon, 1962; Hager and Kirchner, 2013; Sherwin, 2016; Johnson, 2020a, 2020b).

> The signals consist of trains of pulses with a pulse repetition rate of 10–20 Hz. The galleries have physical features that promote vibrational communication and are used as channels for long-distance communication. In M. natalensis, the signal propagation velocity is ~130 m s^{-1} and the signals are attenuated by ~0.4 dB per centimetre distance…. Workers respond by a fast retreat into the nest and soldiers are recruited to the source of vibration. (Hager and Kirchner, 2013)

But who could imagine—much less purposefully invent—an underground warning communication system, operated by centimeter-long sentinels, who knock their noggins upon the ground—repeatedly, rapidly—to sound the alarm? (Choi, 2013; Hager and Kirchner, 2013; Stead, 2013; Sherwin, 2016).

> Kirchner's initial work on termites' long-distance warnings began in the Ivory Coast but because of the political situation he decided travel to South Africa with Hager to carry on his work. As termites are difficult to find outside their colonies, the duo [i.e., Hager and Kirchner] opened up the central chamber of a termite mound and used high-speed cameras to capture in detail how soldiers warn others of unwelcome intrusions. They saw the soldiers raising their heads upwards before bashing them into the ground at speeds of 1.5 m s^{-1}.
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> Using carefully embedded accelerometers to detect [*Macrotermes natalensis* termite mound] vibrations, the duo found that the *M. natalensis* termites drummed their heads rapidly, 11 times per second.
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> Each head bang generated vibrational pulses where the ground vibrated with acceleration amplitudes up to 0.7 m s^{-2}; this approximately corresponds to a 70 nm movement at a frequency of 500 Hz.
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> 'Once we had described the signal, the next step was to look at signal perception—what intensity does the signal have to have in order to be recognisable for another individual?' says Kirchner. To do this, they carefully placed termites into Petri dishes and measured their responses over a range of vibrational frequencies and displacements. They found the termites were most sensitive to frequencies around 500 Hz, as long as the movement of the dish's surface was more than 0.012 m s^{-2} (the equivalent of a miniscule 1–2 nm movement).
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> Satisfied that the soldiers were producing a vibrational signal that other termites could pick up, Kirchner says: 'We looked at how a signal is transmitted from the individual into the soil, how much is it attenuated with distance and how fast can it travel physically.' Mimicking a vibration pulse and placing accelerometers at set distances away from the signal, the team found that the vibrational wave could travel up to 171 m s^{-1}. They found that the vibrations were attenuated by 0.4 dB cm^{-1} and calculated that after just 40 cm the ground would no longer vibrate enough for other termites to pick it up.
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> However, drumming signals can be picked up at much further [sic, farther] distances. Kirchner concludes that the only way this could occur is if there's social transmission [i.e., cooperative relay, like a chain of dominos] of the signal. He likens it to a game of Chinese whispers, where one termite passes on the message to the next, and so forth. Only, in this case, the message is not distorted and it's drumming loud and clear—danger ahead! (Stead, 2013)

Astonishingly, that auditory-vibrational alarm is relayed, from termite to

termite, in mere seconds, like a chain of signal fires! (Compare Monsen 1990 with Hager & Kirchner 2013.)

Yet headbanging termite sentinels do what is impossible, impossible apart from God—they repeatedly strike their heads against the ground of subterranean "galleries" (ventilated nest-mound chambers and networked tunnels, connected to underground "fungus farm" gardens), making woodpecker-like rapid-drumming series of sounds and vibrations (Choi, 2013; Stead 2013; Sherwin 2019).

> Fungus-growing higher termites [especially *Macrotermes natalensis*] build long subterranean galleries that lead outwards from the nest to foraging sites. When soldiers are disturbed, they tend to drum with their heads against the substrate [i.e., floor] and thereby create vibrational alarm signals. (Hager and Kirchner, 2013)

This illustrates how these termites practice ***continuous environmental tracking***, followed by sentinel termite decisional responses. This can be outlined as: information/data intake → built-in logic system/programming for reacting to received "if/then" information → selected responses, that match the situation, ultimately for enabling creature "filling" of specific environment/situation habitats (Guliuzza, 2019).

Thus, the teleology of such sensing → interpreting → reaction series is obvious to see, for those "with eyes to see" God's design for "filling" this habitat.

And this is necessary, because in Africa's savannahs (Choi, 2013), even termites have predators!

How will termites know danger has arrived? The termite mounds are gigantic—they tower in heights impressive to humans, yet compared to the termites themselves their homestead mounds are veritable skyscrapers! In fact, comparing the size of those mounds, to the termites who build them from spit and mud, is like comparing adult humans to twice the height of the Empire State Building (Choi, 2013; Johnson, 2019; Sherwin, 2019).

Also, termite nest-mounds themselves are admirably ventilated, plus termite nest-mound architecture is magnificent in general, as a *hidden-in-plain-view* feat of engineering science (Sherwin, 2019). So, when predatory aardvarks or pangolins (or even ants) break into aerated termite nest-mounds, to consume termites, jeopardized termites need a practical warning alarm security system (Choi, 2013; Hager and Kirchner, 2013). How will at-risk termites warn nestmates to flee?

> The investigators witnessed the soldiers rapidly banging their heads on the ground about 11 times per second, with signals each capable of spreading nearly 15 inches (40 centimeters). Soldiers that received the warning ran to assist their nestmates, while workers retreated. Comparable results were seen with a similar African termite species belonging to the genus *Odontotermes*. The soldiers responded to drumming by drumming themselves. This can spread the alarm much the same way soldiers at the Great Wall of China alerted others by using smoke signals during the day and beacon fires at night, thus spreading the signal along the length of the wall. (Choi, 2013)

Because predatory "home invasions" often occur with rushes of air currents, it is unsurprising (for creationists, who expect to see rational aspects of programmed "filling" of changing environments) that sentinel termites (who are continuously tracking their often-changing environmental conditions) react instantly and defensively to sudden puffs of air (Hager and Kirchner, 2013; Stead, 2013). Such cues of mound-breach danger must be addressed by rapid communication of the peril.

> Defending an extended nest system requires a communication system to inform nestmates in remote parts of the gallery about attacks and holes in the nest wall. The use of vibrational alarm signals that can be rapidly transmitted over long distances would allow fast retreat and defence reactions and would clearly be advantageous. (Hager and Kirchner, 2013)

Accordingly, termite researchers—using high-speed cameras and audio-recording technology—intrusively squirted puffs of air into termite nest-mound material, to trigger (and measure) sentinel "soldier" termite headbanging (Hager and Kirchner 2013). Such headbanging reactions, to air-puff perturbations, can be measured quantitatively, to identify how quickly and how loudly such alarm signals are given headbanging (Hager and Kirchner, 2013). Thus, we can see one of God's "wonders without number" (Job 9:10), thanks to high-tech mound surveillance equipment.

But most of us don't use such high-tech surveillance equipment to record or to analyze the high-speed headbangings of underground termites in Africa.

However, we all can appreciate how the Lord Jesus Christ providentially planned, programmed, and produced these diminutive detritivores—mostly ignored by us, yet not by Him—as those humble headbanging termites illustrate Christ's creative imagination and bioengineering (Revelation 4:11).

Obviously, evolutionary accidents cannot explain—much less invent—such noggin-knocking communicators' design, development, and deeds.

Headbanging termites are alarming, yes, yet we can also admire their purposeful communications as energetic exhibits of Christ's glory as Creator (Revelation 4:11; Psalm 148:10).

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