Prospecting for new types of nanowires in the microbial world could expand the diversity of material properties available for electronic innovation. Further elucidation of the structures and electron-transport mechanisms in known microbial nanowires is likely to lead to advanced concepts for rational design and optimization of microbial nanowires for further applications.

#### DECLARATION OF INTERESTS

D.R.L. declares two U.S. patents: “Microbial nanowires related systems and methods of fabrication” (Patent No. 7,498,155) and “Microbial nanowires with increased conductivity and reduced diameters” (Patent No. 11,066,449).

### *Where can I find out more?*

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# Application of insects to wounds of self and others by chimpanzees in the wild

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Self-medication refers to the process by which a host suppresses or prevents the deleterious effects of parasitism and other causes of illness via behavioural means[1]. It has been observed across multiple animal taxa (e.g. bears, elephants, moths, starlings)[2], with many case studies in great apes[1,3]. Although the majority of studies on self-medication in non-human primates concern the ingestion of plant parts or non-nutritional substances to combat or control intestinal parasites[4], more recent examples also report topical applications of leaves or other materials (including arthropods) to skin integuments[3]. Thus far, however, the application of insects or insect parts to an individual’s own wound or the wound of a conspecific has never been reported. Here, we report the first observations of chimpanzees applying insects to their own wounds (n = 19) and to the wounds of conspecifics (n = 3).

Over a period of 15 months (November 2019–February 2021), we observed a total of 76 open wounds on 22 different chimpanzees (eleven adult males, two adolescent males, one juvenile male, four adult females, two adolescent females, and two juvenile females; Supplemental information). In 19 events, individuals (five adult males, one adult female, one juvenile female) applied an insect to one of their own wounds using the following behavioural sequence: first, they caught an insect; second, they immobilised it by placing and/or squeezing the insect between their lips; third, they placed the insect to an exposed surface of the wound and moved the insect on the surface using their fingertips or lips; fourth, they extracted the insect from the wound with the mouth or their fingers (Figure 1 and Video S1; additional videos at https://youtube.com/c/OzougaSociety). Steps three and four are often repeated multiple times during each event. Though the insect species utilised have not yet been identified, there are several consistencies across all our observations: they appear to be winged, flying insects, given the fast motion used to catch them; the insects are caught from under a leaf or branch; they are ~5 mm in size and usually dark in colour and there was no observation of insect ingestion.

In three other events, we observed different chimpanzees applying or moving an insect not to their own wound, but to the wound of another chimpanzee (Supplemental information). On November 13th 2019, an adult female, Suzee, caught an insect and applied it to an approximately 2 cm open flesh wound on the foot of her adolescent son, Sia. Subsequently, she extracted and re-applied the insect two more times using both her mouth and fingers (Video S1). This was the only event of allo-application involving maternally related individuals.

On October 20th 2020, another adult female, Carol, had been grooming around the approximately 5 cm open flesh wound on the calf of an adult male, Littlegrey. She then caught an insect, and Littlegrey took it from her fingers, put it between his lips and placed the insect to the surface of his open wound. Subsequently, Carol and another adult male, Thea, used their fingers to move the insect on the surface of the wound. A third adult male, Ngonde, then approached them, took the insect out of the wound, placed it between his lips, and re-applied it to the wound. On January 29th 2021, another adult male, Arnold, caught an insect, put it between his lips and then applied it to the surface of an approximately one cm open flesh wound on the right thumb of Littlegrey. He lip-smacked whilst moving the insect on the surface of the wound with his fingertips.

Given the unambiguous context in which the observed behaviour occurred (injured individuals with open flesh wounds), we suggest that they may represent another case of medicative

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**Figure 1. Application of insect to a wound.**
The behavioral sequence of an adult chimpanzee male catching and applying an insect to a wound on his left shin in six frames (A–F). Red circles highlight the object or action of interest in specified frames. (A) the male captures an insect with his left hand; (B) he transfers the insect from the fingers of his left hand to his lips; (C) keeping the insect between his lips, he moves his head and lips towards the wound; (D) the male applies the insect, which is still between his lips, onto an exposed surface of the open wound on his left shin; (E) he moves the insect on the surface of the wound with the index finger of his right hand; (F) the male closely inspects his wound and continues to groom around it with his left hand.

behaviour in non-human animals[2]. Moreover, these observations expand the existing knowledge to include allo-medication of open wounds. However, further systematic research is needed to elucidate the efficacy of the treatment associated with an improvement in healing of wounds, identification of insect species used, and the distribution and acquisition of this behaviour in the Rekambo community.

Furthermore, our observations contribute to the current debate on the existence of prosocial behaviours in non-human species[5–7]. Prosocial behaviours refer to actions that are intended to benefit another, and seem to be driven in humans by empathic concerns for each other[6]. Prosocial behaviours have long posed a problem for evolutionary theory, because it was not immediately clear why organisms might help others in the face of selection operating in the interest of self. Chimpanzees have been suggested as important candidates for studies into the evolution of prosocial behaviors because they participate in a variety of activities that benefit from cooperation, such as territorial patrols, coalitionary aggression, and hunting[8]. However, the literature remains controversial, with some evidence suggesting that chimpanzees lack prosocial behaviours involving the type of empathy that is thought to characterize humans[7], while others argue that their prosocial tendencies exhibit characteristics consistent with empathy[5]. Hence, our observations may add another facet to the ongoing debate on prosocial behaviors and inspire future studies investigating the behaviours surrounding wound care and the potential medicative function of insect-application.

## SUPPLEMENTAL INFORMATION

Supplemental information including one table, methods, detailed descriptions of events and one video are available with this article online at https://doi.org/10.1016/j.cub.2021.12.045.

## DECLARATION OF INTERESTS

The authors declare no competing interests.

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