DISPERSAL OF HUMAN-COMMENSALS AT THE HAUGHTON MARS PROJECT (HMP) ARCTIC FIELD-SITE: IMPLICATIONS FOR THE FORWARD CONTAMINTION AROUND HUMAN HABITATS ON MARS.

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Introduction: Special Regions (SR) on Mars are defined as areas "within which terrestrial organisms are likely to propagate" or "any region which is interpreted to have a high potential for the existence of extant Martian life" [1]. Special regions can be natural (defined as extant SR conditions) or created (defined as human-induced SRs) on Mars. One such created SR on Mars might be the local terrain surrounding a human habitat. If the created SRs adjacent to human habitats are contaminated with human commensals, then the risks for permanently contaminating the site increase dramatically. The objective of our study was to ascertain whether human commensal bacteria and fungi were being dispersed on to the local terrain surrounding the Haughton-Mars Project (HMP) Research Station on Devon Island, Canadian High Arctic; viewed as an analog for a human habitat on Mars. The HMP site is similar to Mars (although less extreme) in that it is set in a cold/dry polar desert with a wide variety of Mars-relevant geologic features nearby, including the 20-km wide Haughton impact crater.

Methods: The HMP basecamp was established in 2000, and has been occupied each summer since then for periods of 1 to 8 weeks. The HMP basecamp is located at N 75° 26′ and W 89° 52′ on the central plateau of Devon Island. In 2000, individual sleeping tents (not shown) were located ~100 m west of the HMP basecamp. In addition, a total of 9 communal tents were constructed in the following order: (1) the geology, biology/kitchen, and media tents were erected on days-1 to -3 (Fig. 1); (2) two separate latrine tents on day-1 (not shown); and (3) the robotics, mess hall/meeting, office/communications, and medical tents were erected during the later course of the field season (~7 weeks from 30-Jun-00 to 10-Aug-00) (Fig. 2). Although additional tents and capabilities were added to the HMP site since 2000, our focus here is on microbiology studies during the 2000-2001 field seasons.

Co-Is Schuerger and Lee landed with the first Twin-Otter flight on 30-June-00 and mapped out the initial soil sampling campaign. The research approach

Fig. 1. *HMP Basecamp after 7 days (06-Jul-00) of occupation looking east. Only the geology (left), biology/kitchen (middle), and media (Discovery Channel; right) tents are erected. The Twin-Otter landing strip is just over the horizon to the left of the butte.*

Fig. 2. *HMP Base Camp on Aug 16, 2000 after 42 days of occupation, looking North. Four additional tents were erected, and some tent functions have changed. From left to right: robotics (orange dome), washroom (wooden hut), kitchen/mess/meeting hall (large blue & white tent), office/geology (small blue/white tent), comms (off-white), biology (off-white), media (orange dome), and medical (off-white). Several ATV trails are now established at camp.*

was to visually identify the approximate locations where all 9 tents listed above were to be located, and collect T = 0 samples of the Arctic soils prior to any human traffic on the sites. Samples were collected by aseptically transferring 40 g of Arctic soils from each

site into sterile 50 cc conical tubes. Samples were collected on 0, 7, and 42 d after the first Twin-Otter flight landed. All samples were kept frozen until they arrived at Schuerger's microbiology lab at the Kennedy Space Center, FL (approximately 2 weeks after samples were collected). Samples were processed on diverse media (i.e., 10 media and biochemical assays were used) in order to identify and estimate the numbers of culturable bacteria and fungi present in the Arctic soils before, during, and at the end of the first field season. Additional samples from the terrains surrounding the HMP basecamp were collected in 2001, 2007, 2010, and 2015. The results presented here focus on the recovery of human commensals from the 2000 and 2001 field seasons.

Results: First, the soil populations of culturable bacteria at the HMP sites on T = 0 (i.e., prior to human traffic) averaged between 2 x 10^3 and 1.4 x 10^4 culturable bacteria per gram of soil (estimated on 10% trypticase soy agar; TSA). Second, after 7 d, the populations within the mess hall, medical, and latrine (not shown in figures) tents increased on average by 2 orders-of-magnitude. Third, at the end of Season-1 (42 d after landing, 10-Aug-00), the bacterial populations increased within the same tents to ~1 x 10^7 to 3 x 10^8 cfu/g of soil or debris. Fourth, culturable fungi were not detected in any of the samples collected on 0 or 7 d after landing, but were recovered inside tent samples on 42 d. The average fungal density per sample was ~5 x 10^4 cfu/g of soil at the end of the season. And fifth, all ATV trails and foot-traffic pathways exhibited only culturable bacteria at densities similar to the T = 0 samples of the HMP site.

A set of soil samples collected at 0, 1, and 3 m exiting one latrine tent and the mess hall tent showed elevated populations of bacteria only at the 0 m (i.e., at the door threshold) sample points while exiting the tents. The 1 and 3 m samples exhibited approximately the populations of culturable bacteria found in the T = 0 samples on 30-Jun-00.

Similar results were observed for the soil samples collected during the 2001 field season between 03-Jul-01 and 15-Aug-01. Elevated populations of bacteria and fungi were only recovered from within the human-occupied tents. All ATV and foot-traffic corridors were similar to T = 0 samples collected on 30-Jun-00.

Discussion: The overall conclusions of the study are (1) that the human commensals within the occupied tents were not transported to external terrains during the 2000 and 2001 field seasons, and thus, the external terrains could be considered as "not-contaminated" by human commensals over a 2-yr period of occupation. And (2), the bacterial populations in soils and debris within the tents increased approximately 4 orders-of-magnitude between the T = 0 samples on 30-Jun-00 and the end of the second field season on 15-Aug-01.

A similar trend for the slow dispersal of human commensals from inside an analog Mars pressurized rover was reported for a 8-d traverse across Arctic sea ice in 2009 [2]. Other studies also have reported low recoveries of human commensals surrounding habitats in extreme environments including the Antarctic [3,4,5] and caves [6].

In the study by Schuerger and Lee [2], samples were collected from the inside floor-boards of a modified Humvee vehicle (called the Okarian rover) during a 496 km traverse over arctic sea ice and from pristine snow/ice sample sites 10-30 m in four directions away from the rover. Ten of 11 snow/ice samples were absent bacterial and fungal contamination. In the single sample with microorganisms present, only 1 bacterial and 1 fungal colony were recovered that were similar to species found inside the Okarian rover.

Results from the current study, and the cited literature above, support the conclusion that human commensals within occupied habitats are not easily dispersed onto pristine external terrains. If confirmed over longer periods of time, the results may indicate that human habitats on Mars will not overtly contaminate the local terrains surrounding the landing sites.

However, we must caution here that the samples collected in 2007, 2010, and 2015 (currently archived at -70 C) have not yet been processed, and that the studies in 2000 and 2001 were conducted without the benefit of modern metagenomic assays. Thus, the low contamination rates indicated above might be slower than actually present in future Mars landing sites.

We are planning new research to return to the HMP basecamp in 2019 to collect what will be ~ 20 years of sequential samples from a human-occupied field site in the Arctic. We plan to apply modern metagenomic assays to characterize the species diversity and abundance of culturable and nonculturable species in all samples in order to develop a microbial dispersal model for cold/dry field sites that are relevant to the human exploration of Mars.

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