The effects of hypercapnic hypoxia on naked mole rat activity levels, memory, and social interaction

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Abstract

In their natural environment, naked mole rats experience low levels of O2. During rainy seasons that floodburrows cannot handle, these creatures depend on their large and extensive burrow systems to increase oxygen intake by increasing carbon dioxide levels and creating a hypoxic environment that minimizes energy and memory loss. The levels of CO2 and O2 in the burrow systems were monitored for this study. The independent variables were the levels of CO2 and O2 in the burrow systems. The dependent variables were the number of movements and memory.

Methods

12 naked mole rats were observed from the laboratory colony ranging from 1 to 7-years-old while undergoing conditions similar to those in their natural habitat. Naked mole rats were housed in single containers and exposed to a mass composed of grains and vegetables to ensure the natural burrowing of the naked mole rats. The independent variables were the levels of CO2 and O2 in the burrow systems, and the dependent variables were the number of movements and memory.

Results

For the first 2 days of the study, O2 levels were kept normal (21%) and movements were tracked via the Toxair 6SP-it under each naked mole rat's skin. Each time a rat passed under one of the 10-sensors, the movement was recorded. For the next 4 days, O2 levels were lowered to 17% (by adding 2% CO2). Rat movements were recorded during this time as well. Finally, O2 levels were restored and movements were tracked for an additional 2 days.

Conclusions

• Results did not support the original hypothesis that activity, memory, and social interaction levels would decrease under hypercapnic hypoxia.

• For memory, average times were significantly longer for normoxia than hypoxia.

• Under hypoxic conditions, overall social interaction increased. Animals interacted with more members of the colony, shown by a 92.5% increase in graph density and 77.9% increase in average degree for hypoxia.

• Naked mole rat activity and social interaction increased under hypercapnic hypoxia. This may be because naked mole rats interpret hypoxia as dangerous and they find strength in numbers.

• Also, the results very possibly point to a flaw in the study. Follow-up studies should be conducted, with oxygen levels significantly lower. The expected significant changes may not have been observed since naked mole rats are so well-adapted to low oxygen environments. With the well being of the animals taken into consideration, oxygen levels should be lowered slowly and under strict monitoring to prevent any harm.

References


Acknowledgements

We used the lab and naked mole rat colony of Dr. Dan McCloskey at the College of Staten Island. We thank the animal care staff and also Dr. Dan McClosky for advice and assistance.

Figure Captions

FIG. 1. A naked mole rat with the characteristic pink, wrinkly skin eating food. This animal dug and lives underground in burrows. Photo courtesy of Wikimedia Commons.

FIG. 2. A maze was set up to measure memory. The cage in the back is the colony common feeding area, and the cage base in this photo is the community toilet. The carbon dioxide maintained hypercapnic hypoxic conditions. All tunnels to track movements were placed around the value. Photos by Nicole Boffa.

FIG. 3. Naked Mole Rat social interaction under Normoxia vs. Hypoxia. A) Degree of centrality (average dot size): 3.286 B) Degree of centrality (average dot size): 5.846

FIG. 4. Naked Mole Rat social interaction and Degree of Centrality graphed by Gephi based on data from Toxair 6SP-it chips and readers. Data represent individual male rats (representative popularity). Black thickness represents its level of interaction.

FIG. 5. A) Normoxia open vs. closed Null Hypothesis: H0: μnormoxia = μhypoxia P-value: 0.1919 > 0.05 so we failed to reject the null hypothesis and couldn't prove statistical significance.

B) Hypoxia open vs. closed Null Hypothesis: H0: μhypoxia = μnormoxia P-value: 0.0275 < 0.05 so we failed to reject the null hypothesis and could prove statistical significance.

FIG. 6. Mean Number of Movements (A) Normoxia (B) Hypoxia

TABLE 1. Number of Movements

<table>
<thead>
<tr>
<th>Condition</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normoxia open</td>
<td>250</td>
</tr>
<tr>
<td>Hypoxia open</td>
<td>190</td>
</tr>
<tr>
<td>Normoxia closed</td>
<td>180</td>
</tr>
<tr>
<td>Hypoxia closed</td>
<td>160</td>
</tr>
</tbody>
</table>

Note: Due to a concurrent study, no further extraneous from this colony were removed midway into the study.

FIG. 7. Naked Mole Rat activity levels, memory, and social interaction levels would decrease under hypercapnic hypoxia.

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Under hypoxic conditions, overall social interaction increased. Animals interacted with more members of the colony, shown by a 92.5% increase in graph density and 77.9% increase in average degree for hypoxia.

Naked mole rat activity and social interaction increased under hypercapnic hypoxia. This may be because naked mole rats interpret hypoxia as dangerous and they find strength in numbers.

Additionally, the results very possibly point to a flaw in the study. Follow-up studies should be conducted, with oxygen levels significantly lower. The expected significant changes may not have been observed since naked mole rats are so well-adapted to low oxygen environments. With the well being of the animals taken into consideration, oxygen levels should be lowered slowly and under strict monitoring to prevent any harm.