Comparative Study on Ventilation Processes: Solutions in Nature and Applications at CasaE-UFRGS

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1. Introduction

Many solutions are found in Nature for the ventilation of dens and burrows in confined environments. The present work aims at studying these different configurations and processes, and their association with the physical principles involved, in order to compare them with the utilization of these principles at CasaE-UFRGS.

2. Methodology

For this work, three habitats were chosen in confined natural environments:(i) the burrow of *Cynomysludovicianus*, or prairie dog, a rodent mammal, which inhabits the prairies of the United States and Canada,(ii) the mound of *Macrotermesmimichaelseni*, a termite, which inhabits the savannas of southern Africa, and (iii) the colony of the *Atta* species of sauba ant. The chosen bibliography, the principal processes of each habitat and the physical principles involved were studied. After reading the bibliography, a visit was made to CasaE-UFRGS for familiarization with the technology used at the house, as much for efficiency as for environmental comfort.

3. Solutions in Nature

In the three cases, the format of the nest or burrow is fundamental to the internal flow of air. This is allowed, for Vogel (1973) regarding the *Cynomysludovicianus*burrow, by the difference in height amongits various entries, as shown in fig. 1. Vogel also observed the Bernouilli principle, which is connected to wind variations along the burrow entries.

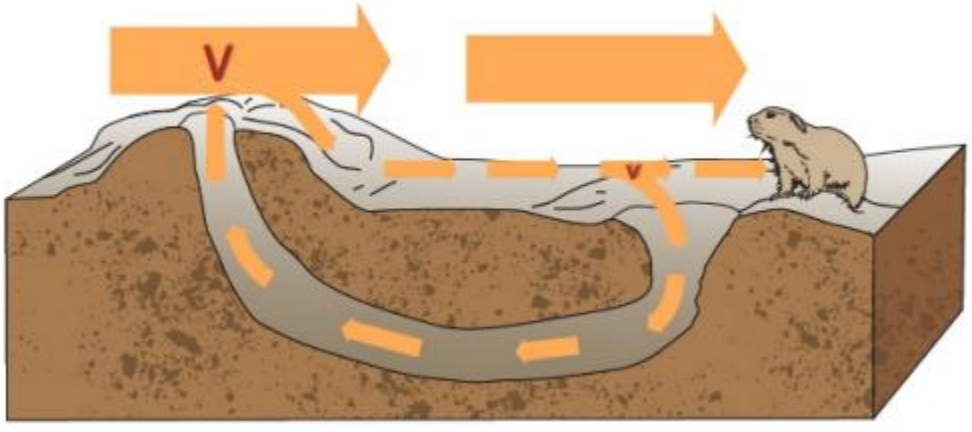

Figure 1: The difference in height between two entriesallows an air flux in the *Cynomysludovicianus* burrow.

Moreover, Turner (2001) observes the process of naturally induced convection in the *Macrotermesmichaelsenium* mounds, illustrated in fig.2. The heat, metabolism, and humidity

create a reduction in air density within the mound, resulting in a force which induces circulation toward the surface. For Martin Lüscher, cited by Turner, the mound of *Macrotermesmichaelseni* functions, essentially, like a heart-lung system.

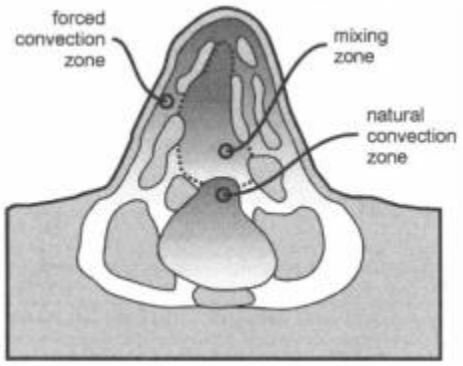

Figure 2: Convection zones in the *Macrotermesmichaelsenium*mound.

According to Bollazzi (2012), entries distributed at different heights in the nests of the leaf-cutting ants of the *Atta* species, as shown in fig.3, constitute a passive system of ventilation, which is also induced by the action of winds, from the Bernouilli principle.

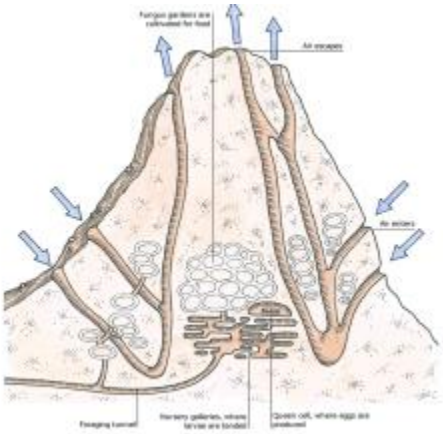

Figure 3: Entries at different heights allow for a passive system of ventilation in the *Atta* ant nest.

4. Comparisons with CasaE

Among the acclimatization systems at CasaE-UFRGS, one that stands out most for this study is the cross ventilation, which functions in two ways: (i) horizontally, through capture of external breezes, and (ii) vertically, as in fig. 4, with an underground entrance (not shown), angled ceiling system, and clerestory.

Figure 4: Natural air convection in a system that includes angled ceiling, solar blind and clerestory is an application of the Venturi and Bernuille effects at CasaE-UFRGS.

With the opening of the clerestory, natural air convection occurs. This results from the reduction of air density with an increase in temperature, differences in height and in pressure caused by the action of wind - as in the *Cynomysludovicianus*burrow, the *Macrotermesmichaelsenium* mound and the *Atta* nest – where the Bernouilli effect is present. Additionally at CasaE, the chimney, or Venturi, effect occurs with the operation of the angled ceiling, through a gradual increase in the cross section area, which can be explained by the continuity of flux.

5. References

1. S. Vogel, C. P. Ellington, Jr., D. L. Kilgore Jr. Wind-Induced Ventilation of the Burrow of the Prairie-Dog, *Cynomysludovicianus*. J. Comp. Physiol. 85 (1973) 1-14.
2. Christoph Kleineidam, Roman Ernst, Flavio Roces. Wind induced ventilation of the giant nests of the leaf-cutting ant *Atta vollenweider*. Naturwissenschaften 88 (2001) 301-305.
3. http://www.ufrgs.br/casae/sistemas/climatizacao/ventilacao-cruzada
4. J. Scott Turner. On the Mound of *Macrotermesmichaelseni* as an Organ of Respiratory Gas Exchange. Biology and Philosophy 19 (2001) 327-352.