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INFORMATION THEORY APPROACH TO COMMUNICATION IN ANTS

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SUMMARY

Ant food searching activity requires the information transmission quantitatively known to the experimentalist. The existence of developed "language" permitting the evaluation of the information transmission rate (bit/min) was found in ants. They are able to use "text" regularities for information coding, "compression".

INTRODUCTION

Nowadays the ethology intensively studies the animal communicative systems and the related intellectual capacities (see Manning 1979). Many workers focused their attention on signaling activity of ants, which are known to use different communicative ways for searching food: chemical trails, sound signals, kinopsis (reaction to the excited scout behaviour), tandems, etc. (Wilson 1971; Hölldobler 1971, 1976, 1982; Hölldobler et al. 1974; Dlussky 1980; Reznikova 1982, 1983). Recently developed experimental methods and filming provided the data on the ant's antennal code (Bonavita-Cougourdan and Morel, 1984). The question on the existence of the developed ant's "language" is still open.

We suggest a principally new approach to study animal language: to investigate just the process of the information transmission. By the "information" we mean the definite quantitative value introduced by Shannon in 1948.

MATERIAL AND METHOD

Experiments provide the situation when in order to obtain food ants have to transmit information quantitatively known to the experimentalist. This information concerns the sequence of turns towards the trough. We used the new laboratory system called "binary tree" where each "leaf" of the "tree" ends with empty trough versus one filled with syrup. The simplest design was the tree with two leaves and two troughs with syrup in one of them (Fig. 1a). In such situation an ant scout should transmit one bit of information to an ant forager: to go to the right or to the left. In other experiments the number of forks in one branch increased up to six (Fig. 1b shows a labyrinth with 4 forks), hence, the number of bits necessary to choose the correct way is equal to the number of forks. The sequence of turns was randomly taken by tossing a coin. Ants were kept in groups of 800 animals each with the female and brood, in plastic transparent nests which provide observations of their contacts. There were groups which had one scout and 7-8 recruits; the

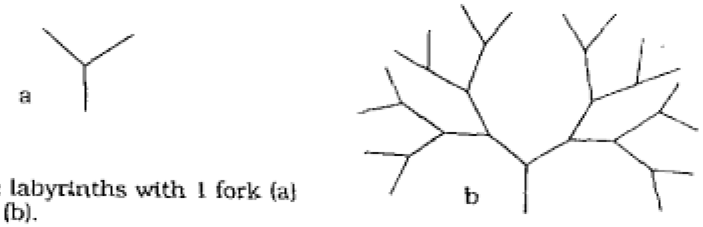

Fig. 1 The labyrinths with 1 fork (a) and 4 forks (b).

scout attracted to the food only the members of his group. We forced the scout to enter the trough, and it independently returned to the nest. In all cases of group mobilization we used a stop-watch to measure the duration of the scout-forager contact. As soon as the ant group appeared on the arena, we isolated the scout and the group has to look for food without its guide. In order to avoid the odourous trail influence, we regularly renewed the labyrinth when the scouts were inside the nest.

RESULTS

Evaluation of the information transmission rate. In our experiments the quantity of information (in bits) needed to choose the correct way towards the trough is i, the fork number. We supposed that the duration of the contacts between scouts and foragers (t) is $ai+b$, where a is the coefficient of proportionality which equals to the rate of the information transmission (bit/min), and b is a constant, since ants can transmit additional information not related directly to the task, that is to the signal "food". From the data obtained we evaluated parameters of linear regression and sample correlation coefficient, r (Tab. 1).

Tab. 1 The parameters of linear regression (a,b) and sample correlation coefficient (r)

Species	r	a	b
Formica sanguinea	0.962	0.738+0.053	-0.763+0.094
Formica polyctena	0.791	1.094+0.050	-0.619+0.460
Camponotus saxatilis	0.967	1.189+0.018	0.334+0.032

In all species studied, the correlation between the duration of the contact and the quantity of information turned out to be close to linear. In 3 species the ratios of the information transmission (a) was 0.738, 1.094 and 1.189 bit/min. We do not consider these values as specific constants as they may vary. Note that these rates are considerably lower than those in man communication.

Information theory tests of ant's intellect. The ability to "catch" quickly the regularities and use them for coding and "compression" of information should be considered as being one of the most important properties of language and its carrier's intellect. Thus the length of the text should be proportional to complication of the information, e.g. it is easier for man to remember and transmit the fork sequence LR LR LR LR LR than the shorter one but random RL LL RR LR. The time of information transmission on the fork sequences in ants turned out to increase with the complication of the task (Tab. 2).

Tab. 2 The time spent by a scout to transmit the information about the way to the trough (1 to 8, "regular" sequences; 9 to 15, random sequences, *Formica sanguinea*)

Sequence	Mean time + S.D.	Number of experiments
1. LLL	72 + 8	18
2. RRR	75 + 5	15
3. LLLLL	84 + 6	9
4. RRRRR	78 + 8	10
5. LLLLLL	90 + 9	8
6. RRRRRR	88 + 9	5
7. LRLRLR	130 + 11	4
8. RLRLRL	135 + 9	8
9. LLR	69 + 4	12
10.LRLL	100 + 11	10
11.RLLLR	120 + 9	6
12.RRLRL	150 + 16	8
13.RLRLRL	180 + 22	6
14.RRLRRR	220 + 15	7
15.LRLLRL	200 + 18	5

The results obtained by this method show that:
1. Ants are able to memorize and transmit 1-6 bits of information.
2. The quantity potential of transmitted information is high (above 200).
3. The duration of the information transmission is proportional to the information quantity.
4. Ants spend considerably less time for transmission of information on regular fork sequences than on random ones of the same length.

REFERENCES

Bonavita-Cougourdan, A., Morel, L. (1984) Les activites antennaires au cours des contacts trophallactiques chez la Fourmi *Camponotus vagus* ont-elles valeur de signal. Insectes Sociaux **31**: 113-131.
Dlussky, G.M. (1980) The principles of ant communication. In: Readings in Memory of Kholodkovsky. Nauka, Leningrad, pp. 3-33.
Hölldobler, B.K. (1971) Recruitment behaviour in *Camponotus socius*. Z. vergl. Physiol. **75**: 123-142.
Hölldobler, B.K. (1976) Recruitment behaviour, home range orientation and territoriality in harvester ants *Pogonomyrmex*. Behav. Ecol. Sociobiol. **1**: 3-44.
Hölldobler, B.K., Moglich, M., Maschwitz, U. (1974) Communication by tandem running in the ant *Camponotus sericeus*. J. Comp. Physiol. **90**: 105-127.
Manning, A. (1979). An Introduction to Animal Behaviour. E. Arnold Publishers Ltd, London.
Reznikova, Zh.I. (1982) Interspecific communication between ants. Behaviour **80**: 84-95.
Wilson, E.O. (1971) The Insect Societies. Harvard Univ. Press, Cambridge, Mass.