Gustatory preferences of ants *(Camponotus compressus)* for urea and sugars

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Summary. Black ants, *Camponotus compressus,* show specific gustatory preferences for urea over a wide range of molar concentrations. On a molar basis the threshold of chemopreference for urea was lower than that for the most preferred sugar, i.e. sucrose.

There is scarcely any sort of organic matter that does not serve as food for one species of insect or another. Some 20% of all species of insects in the tropics are scavengers or saprophagous insects, feeding on dead or decaying animal or vegetable organic matter. The hitherto unreported observation of the ingestion of urine (animal or human), containing no reducing sugars, by ants of the species *Camponotus compressus,* forms the basis of this study.

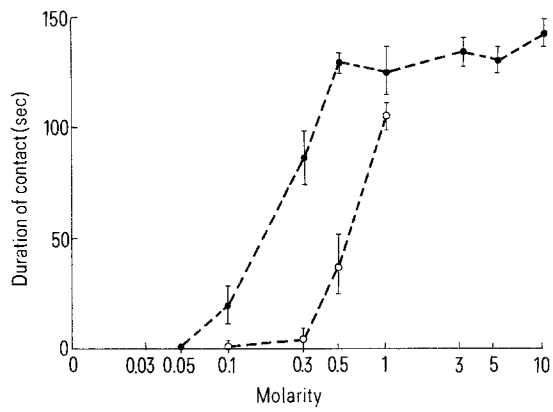
Materials and methods. Contact chemoreception is an important mechanism, influencing and regulating feeding behavior in insects. Extension of the proboscis, duration of feeding and measurement of crop-loads have all been used as reliable indices for measurement of acceptance (or rejection) thresholds[1]. Gustatory preferences of *C. compressus* were determined by the duration of initial uninterrupted contact of the mouth parts of an insect when it was exposed individually to various nutrient or test solutions; a technique similar to that used by Weis[2]. Duration of contact with the solution was related to the degree of distention of the abdominal segment and to weight changes and thus formed an index of preferential ingestion. Statistical comparison showed that the duration of contact with a number of solutions was linearly related to the increase in weight of the insect ($r=0.94$, $p<0.001$), indicating ingestion of the solution. Chemopreferences of the ants were determined at the same time every day (20.00–22.30 h), corresponding to their period of maximum activity, and a minimum of 10 ants were used for each solution.

Results and discussion. Among compounds acceptable to insects, carbohydrates are the most usual and important. Chemopreferences of *C. compressus* for various sugars indicated that the disaccharides, sucrose and maltose were equally preferred, while lactose was not ingested at all. The order of effectiveness of monosaccharides was fructose > glucose > galactose. This compares well with studies carried out on other species of insects, in that, in general, the most stimulating disaccharides are the α-glucosides and the most stimulating monosaccharides are fructose and glucose[3]. Of greater interest, however, is the specific gustatory preference of this species of ants for solutions of urea. Exposure to urea solutions (0.01–10 M concentrations) showed that duration of contact, sufficient to suggest a feeding response, began at 0.1 M, increasing rapidly with increase in concentration and levelling off at concentrations beyond 0.5 M. Comparison of preferences for sugars or equimolar urea showed that 1 M urea was preferred to disaccharides; sucrose and maltose ($p<0.01$); and to monosaccharides; fructose, glucose and galactose ($p<0.001$).

Contact chemoreception is concerned principally with the act of feeding, hence most physiological studies in insects have centred around the feeding response, being utilized as an indicator of the threshold of chemical stimulation. Comparison of the preferences shown for urea and sucrose at various molar concentrations indicated that the threshold for recognition of urea solution as acceptable was 0.1 M while that for sucrose was approximately 0.3 M or higher (figure), i.e. a 3–5-fold increase in concentration was necessary for adequate chemostimulation by sucrose as compared to urea. At all molar concentrations studied, urea was specifically preferred over sucrose (0.5 M, urea > sucrose, $p<0.001$; 1.0 M, urea > sucrose, $p<0.01$).

With insects, the relationship between foods and feeding habits are rather complex and depend on the fact that food possesses characteristic properties that attract and induce an insect to feed, such as taste, odour, etc., and also that food contains substances like proteins and carbohydrates that fulfil the nutritional requirements of the insect[4]. The specific gustatory preference for, and ingestion of urea by *C. compressus* may be explained in one of several ways which take into consideration either one or both these features. Certain species of adult insects, like *Calliphora vicina,* utilize dietary ammonia themselves for amino acid synthesis[5]. It is unlikely that urea ingestion in these ants serves as a source of ammonia for the synthesis of amino acids by the insects themselves, since the enzyme urease is not known to be present in insects[6]. However, many insects have a rich fauna of symbiotic micro-organisms in their gut, fulfilling a number of functions, most of which are nutritionally important to the host. Symbiotic microbes synthesize nitrogenous compounds by fixation of free nitrogen or from metabolic products like urea and uric acid; ammonia being the end product of microbial catabolism and, at the same time, a starting material for protein synthesis[7]. It seems certain that symbiotic microbes perform such functions in vitro. However, there is little experimental proof that they do so when inside the host insect. All species of *Camponotus* so far examined are known to have symbiotes, and each caste of each species appears to harbour them in the mid-intestine[8]. Urea, ingested in large quantities by these ants, may act as a substrate for the micro-organisms for synthesis of amino acids which may be required by the host.

Bacteria also serve as food for certain insects[9]. It has therefore been suggested that the wide choice of decaying organic matter that forms a source of food for insects may possibly be due to the microflora that thrive in such



Duration of contact in sec with test solutions as a function of molar concentration. Comparison of preferences for urea (●) and sucrose (○) shows that the threshold for urea, at 0.1 M, was lower than that for sucrose, at 0.5 M. Urea (1 M) is preferred to equimolar sucrose ($p<0.01$).

substrata. Although these ants are specifically attracted, under experimental conditions, to sterile urea solutions, the possibility that urea serves as a chemical signal for the ingestion of an organic base, bound to be rich in microorganisms and, hence, a potential source of nutrients, cannot be ruled out. Some species of *Camponotus* are known to be fungus-feeding and fungus-growing ants[10]. This particular species is not involved in fungus cultivation[11], so the possibility that urea is ingested as a source of nitrogen for the cultivation of fungus does not arise.

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Chronic exercise does not alter the chronotropic response of isolated rat atria to catecholamines[1]

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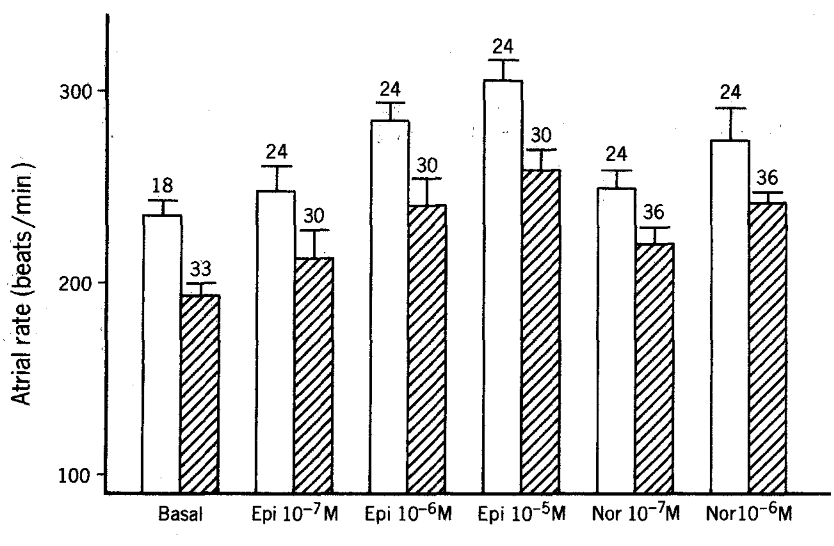
Summary. Atria isolated from rats after 7 weeks of exercise training beat at a slower rate than did atria from sedentary controls. There is no significant difference between the chronotropic responses of the 2 groups to epinephrine or norepinephrine.

The mechanism for exercise bradycardia has been suggested to be an increase in parasympathetic[2] or a decrease in sympathetic tone[3]. It has been shown that chronic exercise increases cardiac acetylcholine content[4] and increases the chronotropic response of isolated atria to atropine[5]. With regard to sympathetic effects, acute exercise has been reported to decrease cardiac catecholamine content[6] or to increase catecholamine synthesis without increasing content[7]. Leon[8] reported no change in heart norepinephrine levels after 3 months of chronic exercise. Raab et al.[9] consider that the non-exercised heart is under preponderant adrenergic control, while exercise exerts an 'anti-adrenergic' effect of the heart. Since this anti-adrenergic effect might mean a reduced chronotropic response to catecholamines, we have undertaken an evaluation of the sensitivity of isolated rat atria to catecholamines following chronic exercise.

Methods. Male Sprague-Dawley rats were assigned to control (sedentary) or experimental (exercised) groups. Experimental rats were run in a 6 compartment motor driven activity wheel twice daily for 1 h, 6 days per week for a total of 7 weeks. The rate of running was 12 m/min. Control rats were quartered with experimentals and were regularly placed in the activity cage, but were not exercised. The animals were sacrificed at the end of the training period and the hearts rapidly removed to a dish of Krebs-Hensleit solution (pH 7.2±0.1). The atria were dissected free and placed in a bath of Krebs-Hensleit solution at 34 °C which was continuously oxygenated with 95% O_2, 5% CO_2. Atrial beats were recorded by means of a strain gauge with



Average rate of beating of isolated atria, basal, and in the presence of the indicated concentrations of epinephrine (Epi) or norepinephrine (Nor). White bars are sedentary controls; shaded bars are exercised rats. Extension bars represent SEM. Numbers over each bar show the number of rats in that group.