Measuring migratory restlessness in captive birds by an ultrasonic system

H. Biebach, H. Wegner and J. Habersetzer

Max-Planck-Institut für Verhaltensphysiologie, Vogelwarte Radolfzell, Radolfzell und Andechs, D-8138 Andechs (Federal Republic of Germany), 30 January 1984

Summary. A new simple ultrasonic system is described with which whirring and hopping, expressions of nocturnal migratory activity in captive birds, can be measured. Pronounced differences are found if the results are compared with those from the most often used perch-microswitch system, which responds only to hopping.
Key words. Birds, captive; birds, migratory restlessness of; ultrasonic system; migratory restlessness.

Day-active, long-distance migrants kept in captivity show restlessness during the night in autumn and spring, the time when free-living conspecifics actually migrate to and from their wintering area. The ability to measure the so-called 'Zugunruhe' in captive birds is the basis for laboratory studies of the mechanisms involved in bird migration. Most often Zugunruhe has been measured as hopping off and onto perches connected to microswitches in the cage[1]. Alternatively Zugunruhe has been recorded by switches which respond primarily to the air movement produced by beating the wings while whirring[2,3]. This method can only be used with small cages and is prone to mechanical failure. The relative amount of hopping and whirring in blackcaps *(Sylvia atricapilla)* and garden warblers *(Sylvia borin)* depends on the light intensity during the night and is species specific[2]. Both hopping and whirring are assumed to be expressions of the degree to which the bird is motivated to migrate.

For a comparative study of Zugunruhe of different species as well as the study of Zugunruhe of one species under different external or internal conditions it is desirable to have a method which records hopping and whirring at the same time. Movements of the body or of the wings are characteristic of both forms of activity. Such movements can be detected by ultrasound sensors which work on the principle of the Doppler effect.

Method. The recording cage for an individual bird is immersed in ultrasound. A receiver with a dynamic input responds only to changes in the reflected frequency, caused by a movement of an object. The extent of a shift in the reflected frequency depends on the size of the object, the direction of its movement relative to the receiver and the speed of the movement.

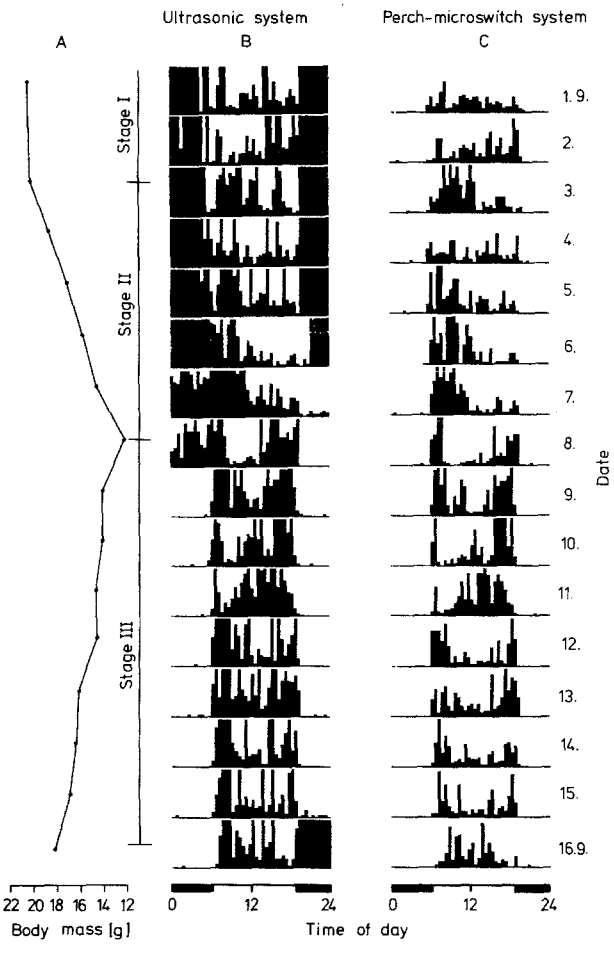
We used ultrasonic sensors (model U-81D) from Advanced Electronic Industry, AEI, Hong-Kong, with a transmitter frequency of 40 kHz which are normally used for theft alarm systems. The system using the highest sensitivity responded to movements of the whole body or to wing flapping but not to movements of only the head or to minor movements of the tail.

To record several birds in the same room it was necessary to separate the cages acoustically. This was achieved by plywood boards mounted between the cages, the top and front side remaining open. To avoid jamming between the different transmitters they had to be electrically connected in parallel.

Results and discussion. During the autumn migratory period of the spotted flycatcher *(Muscicapa striata)* two methods of recording Zugunruhe (hopping versus hopping plus whirring) were compared simultaneously during three physiological stages; high level of body fat (I), depletion of body fat by food deprivation (II) and build up of body fat (III) (fig.). Body weight of the 10 experimental birds was constant between 18 and 21 g during stage 1, decreased at a rate of 1.2 g per day in stage II and increased at a rate of 0.4 g per day in stage III (fig., A).

During the daytime no obvious difference in the activity pattern recorded with the perch-microswitch and the ultrasonic system could be seen in any of the three stages. However, during the nights of stages I and II, Zugunruhe was recorded with the ultrasonic system, but not with the perch-microswitch system. This indicates that whirring without hopping was predominant. Zugunruhe was not measured during stage III with either recording technique.

The result of the experiment; the presence of Zugunruhe during high levels of body fat and during depletion of fat reserves and the absence of Zugunruhe during build-up of body fat, depends very much on the method of recording Zugunruhe in spotted flycatchers. The difference of Zugunruhe as recorded by the two methods certainly depends on the relative amount



Activity measured under natural light conditions by an ultrasonic system (left) and simultaneously by a perch-microswitch system (right) during the migratory period in autumn of a representative (out of 10) spotted flycatcher *(Muscicapa striata)*. The bird had a constant high fat level in stage I, fat content decreased due to food deprivation in stage II and fat being deposited in stage III. Scaling of the y-axis is different in B and C being one unit per 20 impulses of the ultrasonic system and one unit per 10 impulses for the perch-microswitch system. Body weight is given in A.

The ultrasonic system but not the perch-microswitch system indicated that Zugunruhe was present during phases I and II.

of whirring as an expression of Zugunruhe. To demonstrate this problem the example of the spotted flycatcher given here has been chosen because of the big difference it showed between whirring and hopping in the night. Out of the ten birds half of them showed a pattern similar to the example in the figure, whereas the other half showed less difference between whirring and hopping. The spotted flycatcher may be exceptional in its high levels of whirring. In addition, whirring may also have been facilitated by the fact that the cages used were larger than those used in most other experiments[4].
But despite these facts recording Zugunruhe by the perch-microswitch method only may yield too low values for Zugunruhe in other passerines which express part of their Zugunruhe as whirring. Special attention should be given to this problem if different bird species or different physiological stages are compared.

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Glia maturation factor influences recovery from injury in neonatal rat brains[1]

R. Lim and J.F. Miller

Veterans Administration Medical Center, and the Department of Neurology, Division of Neurochemistry and Neurobiology, University of Iowa College of Medicine, Iowa City (Iowa 52242, USA), 22 February 1984

Summary. Newborn rats were injured with a puncture wound in one cerebral hemisphere. Experimental animals were treated with three i.p. injections of Glia Maturation Factor (GMF) at daily intervals starting from the time of injury, whereas control littermates were treated with equivalent amounts of bovine serum albumin. At 25 days old the size of the cerebral cortex at the plane of injury was measured on representative brain sections. In control rats the injured side was 18% smaller than the normal side whereas in GMF-treated animals the difference was only 1%. The results suggest a possible regulatory role of GMF in promoting tissue recovery from brain damage.
Key words. Growth factor; brain injury; brain regeneration; development.

Glia maturation factor (GMF) stimulates astrocytes in culture to proliferate and to undergo morphological and chemical differentiation[2–12]. The chemical changes in these cells include a sequential increase in cyclic GMP[8] and cyclic AMP[7], a rise in the neuroectodermal marker S-100 protein[7], and an increase in the astrocytic marker glial fibrillary acidic protein[10]. The factor also promotes contact inhibition in certain glial tumor cell cultures[9]. Although ample data exist on the in vitro effect of GMF, information on its in vivo function has been lacking. We now present evidence of a biological effect of GMF in the whole animal.
Materials and methods. For this project we used a 10,000-fold purified sample of GMF obtained from beef brains[10,13]. Five litters of 50 newborn rats (Sprague-Dawley) were used for the injury experiment. Animals from each litter were randomly divided into experimental and control groups. Within 24 h after birth, all animals were inflicted with a puncture wound in one cerebral hemisphere by piercing an 18-gauge needle through the cranium in the parietal region, at a point 2.5 mm lateral and 2 mm anterior to the bregma. The needle was directed perpendicular to the surface of the skull, with the bevel facing laterally. The depth of the wound was controlled with a polyethylene sleeve fitted to the needle, exposing a length of 4 mm to the tip. Immediately following the injury, the experimental group was injected i.p. (through a 25-gauge needle) with 50 ng of GMF in 10 µl of 0.2 M potassium phosphate buffer, pH 7.4, while the control group was similarly injected with 50 ng of bovine serum albumin in 10 µl of the same buffer. Thereafter, all rats were returned to their respective mothers. Two additional i.p. injections were given in the two subsequent days without further manipulation of the wound. All animals were sacrificed when 25 days old.
The brains were fixed for 17 h in 10% formalin (buffered at pH 7.0) and trimmed. After dehydration and paraffin embedding, serial coronal sections 10 µm thick were made. Alternate sections were stained with hematoxylene-eosin (H & E) or immunostained for glial fibrillary acidic protein (GFAP), a specific marker for fibrous astrocytes. The latter procedure employed the 'DAKO' PAP kit (Accurate Chemicals, Westbury, N.Y.) using the amino-ethylcarbazole (AEC) chromogen. One representative H & E section, cutting through the area of maximal injury, was selected from each brain and photographed. The image from the negative was projected onto a piece of paper. The area of the projected image outlined by the

Table 1. Summary of means for injured rats not treated with GMF

Group	N	Normal side (n)	Injured side (i)	Difference (n − i)	Ratio (i/n)
Litter 1	2	32.71 ± 0.39	17.22 ± 3.96	15.48 ± 3.58	0.53
Litter 2	6 (3, 3)	30.90 ± 1.83	24.43 ± 3.42	6.48 ± 3.97	0.79
Litter 3	6 (1, 5)	32.82 ± 1.79	27.49 ± 1.58	5.34 ± 1.45	0.84
Litter 4	6 (0, 6)	29.12 ± 1.08	25.27 ± 2.08	3.85 ± 1.05	0.87
Litter 5	4 (2, 2)	29.91 ± 0.86	26.82 ± 2.05	3.09 ± 2.37	0.90
All males	6	30.69 ± 1.35	26.03 ± 3.03	4.66 ± 3.82*	0.85
All females	16	30.79 ± 2.25	25.89 ± 2.49	4.89 ± 2.22**	0.84
All rats	24	30.92 ± 2.00	25.20 ± 3.57	5.72 ± 4.00***	0.82

Values in mm^2 ± SD. Animals in tables 1 and 2 were littermates. Except for litter 1, the sex of individual animals was determined. Numbers of males and females, respectively, from each litter are in parenthesis following N values. *$p < 0.0305$; **$p < 0.0001$; ***$p < 0.0001$ (paired t-test).