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5. One of us (B.F.H.) is the recipient of a career scientist award of the Health Research Council of the City of New York under contract No. I-203.

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Sleep Pattern of Tooth-Grinding: Its Relationship to Dreaming

Abstract. *Simultaneous recordings of brain waves, eye movements, and masticatory muscle potentials throughout the night demonstrate a temporal relationship between episodes of bruxism (nocturnal grinding of the teeth) and periods of rapid eye movements indicative of dreaming.*

Bruxism is the forceful contraction of some of the muscles of mastication occurring during sleep and frequently accompanied by loud grinding or clicking noises. Bruxism affects people of all ages; the incidence in normal populations is unknown. In completing a health questionnaire, 10 percent of the students entering the University of Chicago gave responses indicating possible nocturnal tooth-grinding. Bruxism has deleterious effects on the teeth and supporting structures and its noise often disturbs the sleep of roommates.

We have studied the occurrence of bruxism during the sleep cycle. The subjects we used slept in a laboratory where electroencephalograms (EEG), eye movements, and electromyograms (EMG) from the masseter muscles could be monitored continuously each night. The EEG and eye movements were monitored by well-known techniques which permit discrimination of the four major stages of sleep (*1*) The EMG recording was obtained from two surface electrodes over the masseter muscle on a vertical line between the zygomatic arch and the inferior border of the mandible. A sensitive microphone above the subject's head carried the sounds of contacting teeth to the experimenter who noted their occurrence on the polygraph tracing.

Twelve subjects in whom bruxism was known to occur were observed for 1 or 2 nights each for a total of 14 nights. To define bruxism, we used an EMG recording of at least four times the amplitude of the recording of the basal muscle tone, recognizing that this definition might exclude minor masseter contractions. No masseter contractions which occurred during gross body movements were scored. Sounds of grinding were clearly unreliable indicators of bruxism because massive masseter contractions indicated that noiseless but very strenuous tooth-clenching could occur. The results of these studies are described herein.

Masseter contractions of any amplitude were rare during sleep characterized by high amplitude, slow delta EEG activity (sleep stages III and IV) in agreement with Takahama's report (*2*). Masseter contractions during these stages were usually a concomitant of other body movements and preceded by less than 2 minutes the onset of stage II or of stage I. Masseter contractions were infrequent in stage II of sleep, but not as infrequent as in stages III and IV.

Bruxism was most frequently associated with REM periods (emergent stage I with rapid eye movements) (Fig. 1). Because REM periods are associated with dreaming (*1*), a temporal relationship between bruxism and dreaming is indicated. The difference in the incidence of bruxism in REM and non-REM stages was significant at less than the .001 level (matched *t* test). Masseter contractions occurred at the rate of 20.9 per hour (averaged across nights) during REM periods as compared to 5.3 per hour during non-REM periods. Pilot experiments with four normal subjects showed a similar relationship between sleep stage and masseter contractions, indicating that symptomatic bruxism may represent an exaggeration of a normal phenomenon.

Heightened EMG activity from the masseter leads was observed in conjunction with virtually all large movements of the trunk or limbs. To decrease the possibility that this EMG activity might have represented a spread of electrical activity from other muscle groups, an additional measure was used. Two metal plates were fitted onto corresponding upper and lower molar teeth and arranged in a circuit such that a signal was registered on the polygraph tracing whenever the plates came into contact. Because, at rest, the lower teeth are normally separated from the upper teeth by a space of a few millimeters (*3*), a meeting of the upper and lower teeth could serve as another index of masseter contraction. Virtually all movements of the limbs and trunk were found to be accompanied by a meeting of the upper and lower teeth as well as by EMG signs of masseter contraction.

In the rapid phase of sleep of the cat (corresponding to the REM period in humans) Jouvet noted occasional sudden movements of the jaws and vibrissae (*4*) in addition to the eye movements. He also showed that the occurrence of REM periods demands the integrity of the nucleus reticularis pontis caudalis which is situated in the reticular formation of the brain stem

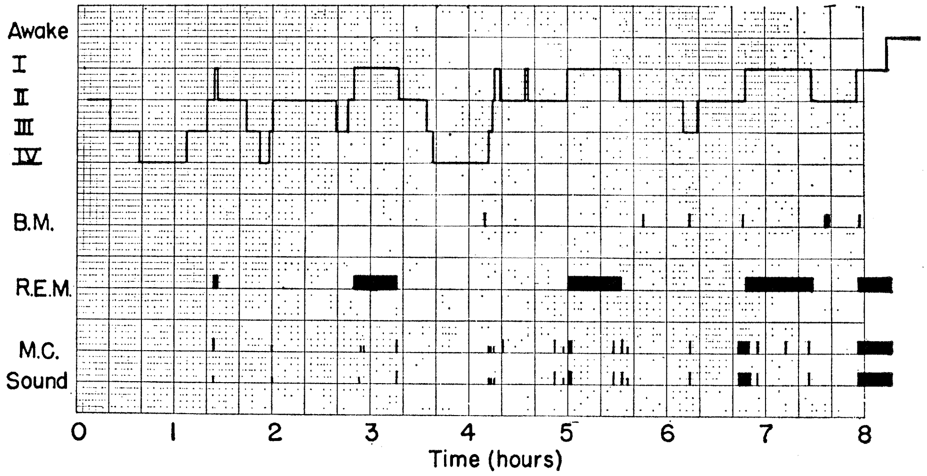

Fig. 1. Sleep pattern of bruxism in one subject during the course of one night. The stages of sleep indicated by the EEG are plotted as I, II, III and IV. Abbreviations: B.M. body movements; R.E.M., periods of rapid eye movements; M.C., masseter contractions; "sound" indicates sounds of bruxism.

(*4*). During the REM period, distinctive spike-like electrical discharges occur in the nucleus reticularis pontis caudalis and appear to spread to various parts of the visual system (*5, 6*). The close temporal association between periods of masseter contractions and REM periods could be explained on the basis of the anatomical proximity (within the brain stem) of the motor nucleus of the trigeminal nerve, which is directly responsible for the contractions of the masticatory muscles, and the nucleus reticularis pontis caudalis. Our preliminary findings thus hold promise for the hypothesis, suggested by Michel *et al.* (*6*), that the spread of activity from the pontine reticular formation may not be confined to the visual system.

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"Male-Producing Factor" in the Wasp Dahlbominus

The discovery of an "inherited male-producing factor" in a hymenopterous insect that produces its males from unfertilized eggs was recently reported by A. Wilkes (*1*). This factor was not identified but was said to be of genetic origin and sex-limited. The genetic situation was anomalous, the influence of the inherited male-producing factor being superimposed on the inherited derivation of all normal males from haploid eggs.

As Wilkes observed, the effect of this factor on the sex ratios of the species studied, *Dahlbominus fuliginosus* (Nees)—an ectoparasite of cocooned larvae of *Diprion* spp.—was "constant and not influenced by the female parent, the host, or the environment." He demonstrated that the effect can be increased and presumably decreased by selection and is independent of the agents previously considered to be responsible for altering the sex ratio of arrhenotokous animals. He concluded that the inherited male-producing factor might account for the remarkable variability of the sex ratio that characterizes many species of Hymenoptera, both in the laboratory and in the field.

Wilkes made the point that the inherited male-producing factor and its effect on sex ratio were contrary to Flanders's understanding of the subject. Such is not the case. Wilkes's presentation of the situation seems based on a misinterpretation of my beliefs concerning sex control in the Hymenoptera (*2*). Twenty-five years ago, after studying in detail the reproduction of various types of Hymenoptera (*3*), I concluded that in the species that reproduce biparentally the sex of the individual is a function of the environment—that the environment operates through the female's spermatheca (a mechanism specialized for bringing the sperm and the egg into contact) and that in the Hymenoptera the spermatheca functions as a sex-changing mechanism when stored with sperm and environmentally stimulated.

The essential features in the process of changing the sex of the egg, the derivation of normal males being from haploid eggs and of normal females from diploid eggs, are (i) the quiescence of the sperm stored in the spermatheca (except when activated by secretions from the spermathecal gland), and (ii) the secretion by the gland of sperm-activating fluids only in response to stimuli associated with the act of oviposition (*4*). The facultative nature of this second feature and the variability in the responsiveness of the spermathecal gland exhibited by individual females appear to be the basis for the sex-ratio variability in the Hymenoptera. Mated females with spermatheca filled with viable sperm may never fertilize their eggs. I found this to be the case with several females of *Macrocentrus* that had deposited their full complement of eggs (*5*). Oviposition was stimulated but not secretion by the spermathecal gland, the essential factor in egg fertilization.

The males from which the unused sperm were derived would be classified as "sterile" according to Wilkes's use of the term. However, it is significant that all of the *Dahlbominus* males, sterile or not, examined by Wilkes were alike in the number and motility of their sperm.

Wilkes in his selections of low-female (SR) lines simply isolated the females characterized by a low glandular response to environmental stimuli, a response that precisely fits the effects characterizing Wilkes's male-producing factor. The "action" of this factor, being negative (a lack of spermathecal stimulation), is of course clearly independent of the agents considered to be responsible for altering the sex ratio of arrhenotokous animals, that is, for changing the sex of the egg from male to female.

Wilkes's failure to fully identify his male-producing factor may stem from a misunderstanding of the phenomena involved in the reproduction of the Hymenoptera. This is indicated by a misinterpretation of certain concepts derived from my 1946 paper (*2*). Thus he says, "Unlike what Flanders believes to be the situation in arrhenotokous species, females of *D. fuliginosus* cannot control fertilization of their eggs. . . ." My belief, based on quite adequate data, was and is that the environment acting through the female's spermatheca controls the fertilization of the egg. Again he says, "From the records of adult emergence, the sperm taking part in fertilization appears to have been random, and not selective as has been suggested for this as well as other arrhenotokous species by [Flanders]." To my knowledge, no one has suggested that in the Hymenoptera the sperms taking part in fertilization were selected on other than a quantitative basis. The structure of the chalcidoid spermatheca permits numerical selection, such as one sperm at a time, from the number present therein (*3*). It is noteworthy in this connection that the sperm nucleus as well as the egg nucleus when developing separately are male producing (*6*).

Wilkes's observations do not preclude the possibility that his male-producing factor is merely an inherent low responsiveness of the spermathecal gland to environmental stimuli associated with oviposition. Wilkes could determine the validity of this conclusion by propagating his high-female lines on several host populations (*Diprion* spp.) that differ either in kind or in size.