Table 1. Occurrence of spontaneous electrical activity in the cerebral ganglia of diapausing and active insects.

Physiological stage	Electrical activity (No. of insects) +	−
Bupalus piniarius		
Diapause	8	1
Development	8	1
Hylocius pinastri		
Diapause	3	
Leptinotarsa decemlineata		
Active	5	
Diapause	7	
Panolis flammea		
Diapause	8*	2
Hyalophora cecropia		
Diapause†	2	1
Diapause‡	1	2
Diapause§	2	

* One pupa did not show any sign of adult development. † After storage at 25°C the insects were kept at 3°C for 5 weeks and subsequently at 10°C for 2 days before being tested. ‡ These pupae spent 2 weeks at 3°C immediately before the experiment. § These insects did not form a cocoon before the pupal moult, but there was no indication of an abnormal diapause.

ment and thus were considered as "developing." Diapausing insects kept for 1 to 2 weeks at 25°C after pupation showed a respiration intensity of 106 ± 16 μl of oxygen per gram per hour. This value is somewhat lower than that for specimens of this species tested for electrical activity previously (*3*). (v) The *Hyalophora* pupae were obtained from larvae reared on lilac at 25°C and under long-day conditions. After pupation the insects were stored at 25°C for 12 weeks. Subsequently, some of them were chilled for 2 to 5 weeks before being tested.

Electrical activity was determined by inserting the active electrode into the brain at several places successively. Electrical activity during one or more penetrations was considered positive (+, Table 1). With the electrodes used, the values of the recorded action potentials were between 50 and 150 μv. Occasionally higher potentials (up to 600 μv) were recorded.

There was spontaneous electrical activity during diapause in all insect species mentioned (Table 1). In the cecropia pupae this phenomenon occurred in five of the eight specimens. Even in these, often only one of the insertions gave a positive reaction. However, with this method of recording, more stress should be laid upon a positive than on a negative result because in the latter case the possibility remains that an active center was present but that it was missed by the insertion. The chance of a miss is probably greater in cecropia. It seemed much more difficult to penetrate the brain of cecropia without causing great damage than it was to penetrate the brains of the other species, possibly because of differences in mechanical properties of the perilemma. But also quantitative differences in activity between cecropia and other species may result in a lower number of positive insertions in cecropia. The latter view is favored by the observation that, in contrast to the other species, electrical activity from cecropia was never recorded when the active electrode was applied to the brain surface only.

If there is a quantitative difference in brains of diapausing and nondiapausing insects, it is not very conspicuous in *Bupalus* and *Leptinotarsa*. In *Hyalophora*, however, it is conceivable that in diapausing brains the records were obtained from active regions, whereas other parts of the brain may be characterized by the disappearance of all electrical activity (and in this case the total amount of cholinesterase may be very low). This hypothesis might explain the discrepancy between the data of Van der Kloot (*1*) and our observations on cecropia. As an alternative explanation one may assume an incomplete diapause in our cecropia pupae. In this context, it is interesting to note that, possibly because of the rearing conditions of the larvae, cecropia pupae are sometimes able to start adult development without any chilling (*5*).

After the demonstration of electrical activity in the brains of *Bupalus*, the concentration of cholinesterase in diapausing and active *Bupalus* specimens was determined. Brains of 105 pupae and 16 adults were excised and cholinesterase was measured manometrically (Table 2). A measurable amount of enzyme is present during diapause, but its concentration rises appreciably in the adult.

Table 2. Cholinesterase activity in the brains of *Bupalus*, both pupae and adults. The brains were excised from diapausing pupae which were kept after pupation at 25°C for 0 to 2 days (I) or for 12 to 25 days (II). The brains of the adults were collected 2 to 4 days after emergence.

Developmental stage	Cholinesterase activity per brain (μmole acetylcholine hr^{-1})
Pupae (I)	0.036
Pupae (II)	.036
Adults	.250

In cecropia, a study of the brains of diapausing pupae showed that the activity of the enzyme was less than 0.05 μmole of acetylcholine per brain per hour (*1*). In *Bupalus*, the activity per brain in diapausing pupae appeared to be somewhat lower. However, considering the smaller dimensions of this brain, it may be concluded that the cholinesterase activity during diapause exceeds that in cecropia.

That cholinesterase is present in *Bupalus* in the brains of diapausing pupae fits well with the observed spontaneous electrical activity. The demonstration of this electrical activity in the other insect species allows the conclusion that this nerve activity in the brains of diapausing insects seems a rather common phenomenon. Thus cecropia may represent an exceptional case because of the disappearance (partial?) of electrical activity.

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Gastric Content of Fasted Primates: A Survey

Abstract. *The acidity of the gastric contents of fasted members of seven families of primates was measured, and no relationship was found between acid concentration and phylogenetic development; in general, however, gastric acidity was higher in New World monkeys than in Old World monkeys. The administration of histamine increased gastric acidity.*

More and more primates are being used in research, and biological studies in several species of monkeys formerly uncommon to the laboratory have become desirable. Gastroenterologists have recently shown that certain New World species have a markedly different gastric acid pattern from the more widely used rhesus monkey (*1, 2*). Hence we surveyed several species to determine whether there was any relationship between the phylogenetic development, or the habitat of the animals, and the amount of acid in the gastric juice.

Twenty-seven monkeys were housed

in individual cages in a room with high humidity and an ambient temperature of 85°F; they were fed a mash high in protein and fat, supplemented with multiple vitamins; they had free access to fresh water. All the animals were treated with diethylcarbamazine and thiabendazole for parasite infestation. Gastric juice was collected through a modified Thomas cannula implanted in the most dependent portion of the stomachs of monkeys, under ether anesthesia, and through a stomach tube from a chimpanzee. After recovery from the operation and prior to the first control collection of gastric juice, the monkeys were allowed to become accustomed to the restraining chair which was to immobilize them during actual collection, for two trial periods of 6 hours each. The monkeys were deprived of food for 24 hours, and their stomachs were washed out with warm tap water 18 hours before each test. The gastric contents were collected in a plastic test tube attached to a Lucite connector fitted to the cannula. The collected juice was centrifuged, and the volume was measured in a graduated test tube. Free and total acidity were measured on a Beckman Zeromatic *p*H meter by titration with 0.01*N* NaOH to *p*H 3.5 and 8.5. Histamine in cumulative doses of 0.05, 0.1, and 0.4 mg/kg (base weight) subcutaneously and methacholine in doses of 0.02, 0.2, and 2.0 mg/kg, administered intraperitoneally, were injected at the start of each collection period. The effect of the drugs was measured by comparing the stomach acidity of the animals to which the drugs had been administered with the stomach acidity of the same animals tested in a control run between each drug trial.

Data on gastric content for nine species of fasted controls from seven families are shown in Table 1. They indicate that, in this rather limited survey, while there was no apparent relationship between the place on the phylogenetic scale and the amount of free gastric acidity in the gastric content, monkeys from the Old World usually had lower free acid than those from the New World. The lack of free gastric acidity in the Old World primates agrees with reports of achlorhydria in rhesus and African green monkeys (*3–5*). In the New World monkeys, the concentration of gastric acid was much higher than in the Old World monkeys, except for the black-capped capuchin which has gastric acidity similar to the African green monkey. The spider monkey, a New World ceboid, has free gastric acidity of 31 to 88 meq/liter in restrained animals (*1*), similar to that in the squirrel monkey.

Table 1. Gastric contents of fasted primates during 6-hour collection period.

Habitat	Common name	Av. wt. (kg)	Animals (No.)	Experiments (No.)	Volume (ml/hr)	Average (meq/liter) Free acid	Average (meq/liter) Total acid
	Lorisoids: *Nycticebus coucang*						
O*	Slow loris	0.700	2	3	0.8	4	22
	Hapaloids: *Tamarinus nigricollis*						
N†	Black-necked moustached tamarin	0.280	1	1	0.1	44	88
	Pithecoids: *Saimiri sciurea*						
N†	Squirrel monkey	0.627	5	20	2.2	69	89
	Ceboids: *Cebus capucinus*						
N†	White-throated capuchin	0.876	5	17	3.0	35	72
	Cebus apella						
N†	Black-capped capuchin	0.853	3	10	1.5	7	39
	Cercopithecoids: *Cercopithecus aethiops sabaeus*						
O*	Green monkey	2.200	5	14	2.5	6	35
	Cynopithecoids: *Macaca mulatta*						
O*	Rhesus monkey	1.9	5	16	3.5	1	18
	Macaca speciosa						
O*	Stump-tailed macaque	4.3	1	3	9.6	0	20
	Simioids: *Pan satyrus*						
O*	Chimpanzee	11.3	1	1	3.6	0	12

* O, Old World monkeys—Africa, India, Asia. † N, New World monkeys—Central or South America.

Histamine increases gastric acid concentration in squirrel, spider, and rhesus monkeys (*1, 2, 4*). In our study, low doses of histamine (0.05 and 0.1 mg/kg) had little effect on acidity or volume of gastric contents in most species. However, a cumulative dose (0.4 mg/kg) increased volume markedly in the slow loris, African green monkeys, and a stump-tailed macaque, with little or no change in volume in the other species. This dose also increased gastric acid concentration in all species (drug effects were not studied in the tamarin or squirrel monkey). The most marked effect was in controls that had little acidity.

On the average, free acid values in milliequivalents per liter after the cumulative dose of 0.4 mg/kg of histamine were: slow loris, 60; white-throated capuchin, 62; black-capped capuchin, 37; African green monkey, 52; rhesus monkey, 14; stump-tailed macaque, 33. These values are above control values shown in Table 1. Methacholine (administered subcutaneously), which increases gastric acidity in dogs (*6*), did not increase gastric acid concentration in the monkeys at any of the doses tested (0.02 to 2.0 mg/kg).

In the chimpanzee, gastric contents collected initially through an intranasal Levin tube had free acid concentration of 44 meq/liter and total acid concentration of 65 meq/liter. However, during a 6-hour control period, after removal of the juice pooled in the stomach, there was no free acid, and total acid was 12 meq/liter. The struggling of the animal on being placed in the restraining chair and during passage of the stomach tube may have produced a temporary increase in gastric acid. A dose of histamine (0.2 mg/kg) given subcutaneously after 60 minutes increased volume and free and total acid concentration to 87 and 110 meq/liter.

On the whole our survey indicates that higher acid concentrations of gastric acid could be expected from Central or South American monkeys than from African, Indian, or Asian monkeys and that, in all species of primates studied, the administration of histamine increases acidity. From the viewpoint of spontaneous acid secretion for physiological and pharmacological studies, the squirrel monkey appeared to be the most useful primate.

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