Central nervous system control of mucous gland secretion from frog skin[1]

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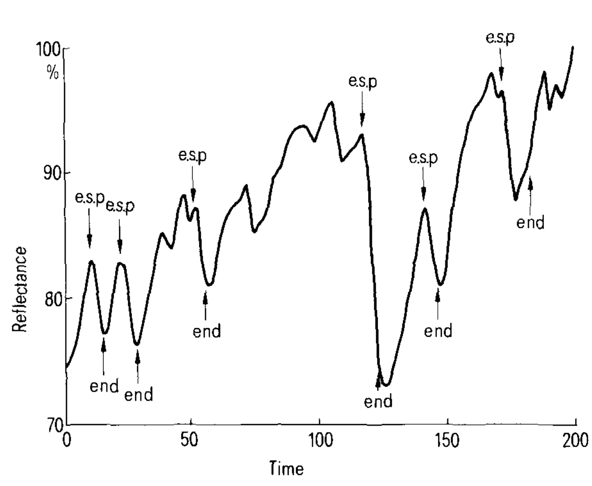
Summary. Surface electrical stimulation of the diencephalic roof of the frog, *Rana berlandieri forreri*, brain initiates integumental mucous gland secretion which is abolished by pithing.

Glandular skin secretions of amphibians have long been studied for their evolutionary relationship to mammalian sweat glands. There are at least 2 types of skin secretion in the frog, both controlled by the autonomic nervous system: 1. granular, characterized by a toxic, milky-white fluid[2]. This class is usually restricted dorsally between the tympanic membranes and the anal opening and is probably released as a defense mechanism, and 2. mucous, bearing a nontoxic, clear liquid released over a much wider area of the animal's integument. Mucous glands are thought to facilitate in thermoregulation of the frog[3]. Activation of fluid release from both glands develops following release of neurotransmitter from nerve endings on the surrounding myoepithelial cells[4,5]. Adrenergic receptor stimulation[6,7] induces a contraction of these cells and concomitant glandular release. Mucous secretion is more of a pulsed event than granular secretion, requiring at least a several second interval between gland excretions. This report deals with our observations on central nervous system control of mucous gland secretion.

Methods and materials. Both adult male and female frogs, *Rana berlandieri forreri*, averaging 160 g were used in this study. Injections into the dorsal lymph sac of 1 mg tubocurarine chloride, a muscle paralytic, immobilized the animals for surgery. After displacement of a flap of skin over the brain casing, a 3 mm^2 piece of the skull was removed just caudal to the eyes. All other tissue over the brain except the pia mater was removed.

For brain stimulation, a twisted, stainless-steel bipolar electrode (75 μm exposed tip) was manipulated down onto the surface. A Grass SD-5 stimulator passed up to 200 μA of current for 10 sec at 100 pulses/sec, 0.5 msec pulse duration, through the electrode. Stimulus parameters were monitored on a cathode-ray oscilloscope.



Relative reflectance changes, as a measure of mucous gland secretion, taken from the leg of a frog. At the times indicated by the downward pointing arrows 10-second trains of electrical pulses were sent to the dorsal roof of the brain by electrodes planted on its surface. (e.s.p., electrical stimulation of paleocortex; end, indicates the time at cessation of stimulus; time is in sec).

The secretion of mucous from the dermal skin glands was determined in 2 ways. First, the dorsal leg of an animal was staged under a 60× dissecting microscope. Mucous secretion was observed as the sudden appearance of tiny, clear droplets forming above the pores. The 2nd method consisted of placing a photoelectric reflectometer (Photovolt) 4 mm above the calf of one of the legs. Whenever fluid emission commenced from the epidermis, a reflectance change ensued and was picked up by the photocell. The photocell was tied into a stripchart recorder to obtain a permanent record of the secretory events.

Results and discussion. Electrical stimulation of the surface of the frog brain initiated synchronous skin gland secretion (figure). The perimeter of effective stimulation was at least as wide as the trephine hole and covered an area from the dorsal optic tecta to the cerebral hemispheres. The latency between stimulation and the 1st sign of mucous release was normally from 1.0 to 6.0 sec. The secretion was apparently a transient event, a typical pulse lasting as brief as 1 sec. No continuous lumenal flow was observed. Successive stimulations released more fluid and as the initial exudate grew larger, the droplets merged to form an uninterrupted sheath over the epidermis. Bidirectional spinal pithing abolished this stimulus-induced mucous secretion.

An 1872 experiment by Engelmann[8] demonstrated mucous gland secretion following direct electrical stimulation of amphibian skin. He also observed that transection of nerves leading to the integument inhibited the animal's ability to discharge mucous. Furthermore, Lillywhite[9] showed that heating of the head of *Rana catesbeiana* lead to mucous release while local heating of the skin had no effect. This evidence established that secretion is probably under central autonomic nervous control. Consequently, while the animal is daytime basking, thermoreceptive cells in the brain[10] may pick up environmental cues and initiate glandular response thereby regulating body temperature.

We suggest that electrical stimulation of the dorsal surface of the frog brain excites a thermoregulatory system, relaying autonomic information via cutaneous peripheral nerves, to induce mucous gland secretion. Future study of amphibian skin secretions may be helpful in elucidating mechanisms involved in various behaviors, as mucous is released in response to a number of stimuli, including visual movement, sound and touch.

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