# Electrical slow waves in oviductal smooth muscle of the guinea-pig, mouse and the immature baboon[1]

A. Talo and B. J. Hodgson*

*Department of Zoology, University Turku, SF-20500 Turku 50 (Finland), and Department of Obstetrics and Gynecology, The University of Texas Health Science Center at San Antonio, Center for Research and Training in Reproductive Biology and Voluntary Regulation of Fertility, 7703 Floyd Curl Drive, San Antonio (Texas 78284, USA), 29 June 1977*

*Summary.* Oviducts of the guinea-pig, mouse and immature baboon show prominent electrical slow waves. In the guinea-pig oviduct they are 40–50 mV in amplitude and have a duration of 1.5 sec in the isthmus. Slow waves in these tissues propagate at a speed of 1–13 mm/sec.

Rhythmical oscillations of the membrane potential (slow waves) of the smooth muscle of the intestines have been studied extensively[2]. Slow waves of the smooth muscle of müllerian organs such as the uterus and oviduct have been less well characterized. Anderson[3] described slow pacemaker potentials of several mV in amplitude and which are very regular in the estrogen-dominated rat uterus. Osa and Katase[4] have shown that the circular muscle of the pregnant rat myometrium is dominated by slow potential changes of 20–30 mV in amplitude. There are only 2 published reports of slow waves in oviductal tissue. Tomita and Watanabe[5] recorded slow waves from the gui-

* Decreased 6th December 1977.

1 Supported by NIH-09339-02 and Rockefeller Foundation. A. T. was a Rockefeller Foundation Fellow. Correspondence to B. J. Hodgson, Dept. Obstetrics and Gynecology, UTHSCSA, San Antonio, Texas 78284.

2 C. L. Prosser, Ann. Rev. Physiol. *36*, 503 (1974).

3 N. C. Anderson and F. Ramon, in: Physiology of Smooth Muscle, p. 53. Ed. E. Bülbring and M. F. Shuba, Raven Press, New York 1976.

4 J. Osa and T. Katasa, Jap. J. Physiol. *25*, 153 (1975).

5 T. Tomita and H. Watanabe, Phil. Trans. R. Soc. Lond. B. *265*, 73 (1973).

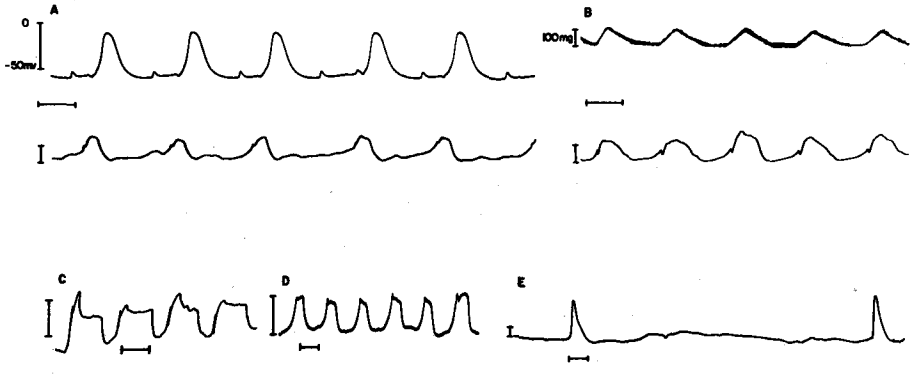


Fig. 1. Slow waves recorded from guinea-pig oviduct. All voltage scales are 2 mV unless specified and time scales (horizontal) are all 2 sec. *A* Recordings from microelectrode (upper trace) and suction electrode (lower trace); electrodes are 3.5 mm apart; *B* longitudinal tension from short segment of oviduct (upper trace) and electrical activity (suction electrode, low trace); *C* and *D* recordings from isthmus and *E* recording from ampulla; all from suction electrodes.

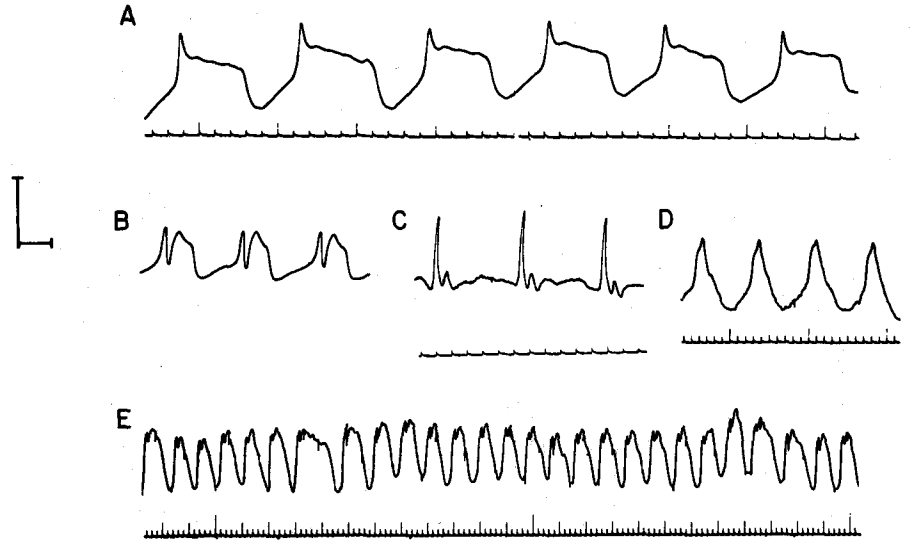


Fig. 2. Waveforms recorded from mouse oviduct with suction electrodes. *A* and *C* proximal isthmus, estrus; *B* Proximal isthmus, proestrus; *D* ampullary-isthmic junction, estrus; *E* distal isthmus estrus. Vertical scale is 0.2 mV except for A, where scale is 0.5 mV. Horizontal (time) scale is 2 sec for A, B and C, 4 sec for D and 6 sec for E.

nea-pig oviduct using the sucrose-gap technique but did not state the location along the oviduct or the hormonal condition of the animal. Nelsen[6] recorded slow waves from rabbit oviduct using extracellular needle electrodes but the relationship of these slow waves to activity recorded using suction electrodes in which no prominent slow waves have been observed[7] is unclear. We report observations of slow waves in the postovulatory guinea-pig oviduct recorded using intracellular microelectrodes and suction electrodes and in the mouse and immature baboon oviduct using suction electrodes.

*Methods.* 4 cycling Hartley White female guinea-pigs were killed by cervical dislocation 18–20 h after rupture of the vaginal membrane; 3 of the animals had ovulated as evidenced by ovarian ovulatory stigmata and subsequent recovery of ova from the oviducts. 6 cycling mice (4 in estrus and 2 in proestrus) were killed by cervical dislocation. 3 immature (3-year-old) baboons were anesthetized with ketamine and the uterus and oviducts were removed. Oviducts were placed in a 10 ml organ bath through which oxygenated (95% $O_2$ + 5% $CO_2$) Tyrode's solution at 37 °C flowed at a rate of approximately 1 ml/min. Glass

6 T. S. Nelsen, T. A. Nunn and J. B. Angell, in: Ovum Transport and Fertility Regulation, p. 75. Ed. M. J. K. Harper, C. J. Pauerstein, C. E. Adams, E. M. Coutinho, H. B. Croxatto and D. M. Paton, Scriptor Copenhagen 1976.

7 A. Talo, in: Ovum Transport and Fertility Regulation, p. 161. Ed. M. J. K. Harper, C. J. Pauerstein, C. E. Adams, E. M. Coutinho, H. B. Croxatto and D. M. Paton. Scriptor, Copenhagen 1976.

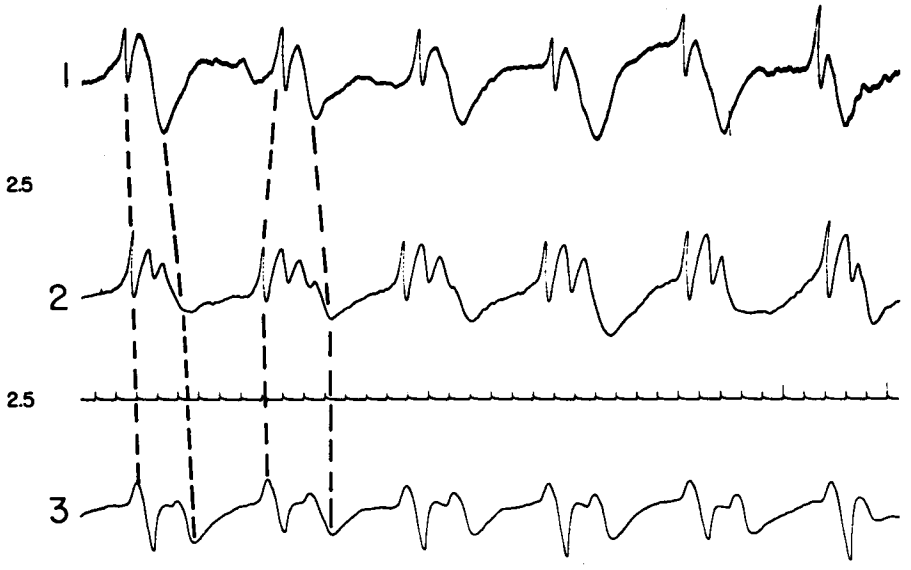


Fig. 3. Spread of slow wave and spike component in the proximal isthmus of proestrus mouse oviduct. Interelectrode distance are 2.5 mm and time constant is 0.15 sec for electrodes 1 and 3 and DC recording in 2.

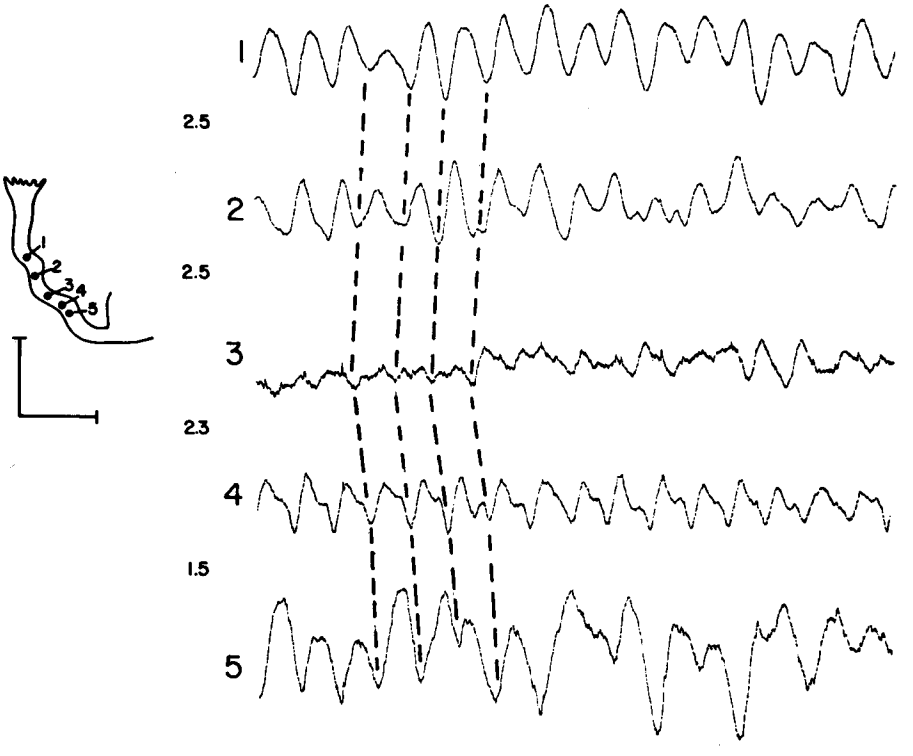


Fig. 4. Slow waves recorded from immature baboon oviduct. Electrode locations (1–5) and separation in mm shown at left. Vertical scale is 0.2 mV and horizontal scale is 2 sec.

microelectrodes were filled with 3M KCl and had a resistance of 30–50 MΩ. Suction electrodes were made of polyethylene tubing drawn under heat to 300–400 μm tip diameter; a silver wire passed to the tip of the electrode. A silver-silver-chloride electrode placed close to the tissue served as the reference electrode. DC electrical signals were recorded using WP-Instruments electrometers connected to a Beckman Dynograph or a Grass 7P Polygraph with DC amplifiers. Using this system, the suction electrodes recorded monophasic slow waves (5–10 mV) and action potentials (10–15 mV) from rabbit jejunum.

*Results.* Slow waves recorded from the isthmus of the post-ovulatory guinea-pig oviduct with microelectrodes (figure 1A) were 40–50 mV in amplitude, 1.5 sec in duration, had a rate of rise of approximately 0.2 V/sec and had a frequency of about 15/min. Slow waves recorded with suction electrodes (2–4 mV) were either notched on the rising phase (figure 1A, 1B) or had a single spike on the rising phase (figure 1C, 1D). Slow waves coincided with increase in longitudinal tension (1B) and propagated at about 7 mm/sec, usually in the fimbrial direction. In the ampulla slow waves were less frequent and decayed more rapidly (1E).

Slow waves recorded from the proestrus and estrus mouse oviduct with suction electrodes (0.2–1.5 mV) resembled those of the guinea-pig oviduct. They spread with a speed of 1–5 mm/sec. The frequency was higher in the isthmus (7–13/min) than in the ampulla. In the isthmus a spike component could often by distinguished on the rising phase of the slow wave (figures 2A, B, 3B) or on the top of the slow wave (figure 3A). The duration of the spike was 0.5 sec or more and since its amplitude in relation to that of the slow wave varied, as did the duration of the slow wave (figure 2E), the components of the resulting wave form were often difficult to interpret (figures 2C, D). Slow waves and spikes propagated in both directions. In some cases the spike appeared to spread independently of the slow wave (figure 3) and in the opposite direction. In such cases the spike appeared during the late phase of the slow wave. Slow waves of the immature baboon oviduct were more difficult to record (amplitude 0.1–0.5 mV), had a relatively high frequency (mean frequency in 5 oviducts was 46.4 ± 3.9/min) and propagated from the ampullary-isthmic junction in both directions at 10–13 mm/sec (figure 4). Only 1 oviduct showed local spontaneous contractions (observed with a dissecting microscope) and contractions coincided with single spikes in an electrode which did not show slow wave activity.

*Discussion.* Tomita and Watanabe[5] suggested that the notch on the rising phase of the slow wave of the guinea-pig oviduct was due to 2 separate components of the slow wave. However, our data suggest that notching may be due to activity of the 2 layers of muscle in the isthmus, since notching was not observed in the ampulla, where there is no inner longitudinal muscle layer, nor in intracellular recordings. Spikes and notches appeared to be related to visually observed contractions, but it is uncertain whether spikes originate in the inner longitudinal muscle or the thicker circular muscle layers.

Slow waves of the mouse oviduct were similar to those recorded from the guinea-pig oviduct, but in some cases spikes and slow waves can be dissociated. This phenomenon has been reported to occur in cat intestine[8]. Slow waves of the immature baboon oviduct propagated at a velocity similar to that observed for spikes in human oviducts[9]. Slow waves originated from the ampullary-isthmic junction (AIJ), and if such directionality occurs in the mature animal may account for the observation that the AIJ represents the major site of delay in ovum transport in this species[10]. Slow waves of the guinea-pig, mouse and baboon oviducts probably regulate the period of spikes and hence contractions as they do in other smooth muscles. Their ionic mechanism and regulation by hormones requires further investigation.

8 P. C. Specht, Am. J. Physiol. *231*, 228 (1976).
9 E. E. Daniel, P. Lucien, V. A. Posey and D. M. Paton, Am. J. Obstet. Gynecol. *121*, 1046 (1975).
10 C. A. Eddy, T. T. Turner, D. C. Kraemer and C. J. Pauerstein, Obstet. Gynecol. *47*, 658 (1976).

## The effects of age and nutritional state on m. e. p. p. amplitude

S. S. Kelly[1]

*Department of Physiology, University of Liverpool, P. O. Box 147, Liverpool L69 3BX (England), 1 July 1977*

*Summary.* A quantitative restriction of food intake for 7 days reduced the amplitude of spontaneous miniature endplate potentials by about $^1/_3$ in rats aged 30 days but not in rats aged 110 days.

The amplitude of spontaneous miniature endplate potentials (m.e.p.p.s) in rat phrenic nerve-diaphragm preparations decreases by more than $^1/_3$ as the animals increase in b.wt from 60 g to 300 g (i.e. from 23 to 56 days of age)[2]. In the present investigation a quantitative restriction of the food intake has also been found to reduce m.e.p.p. amplitude.

*Materials and methods.* Phrenic nerve-diaphragm preparations were removed under ether anaesthesia from male albino rats, strain CFHB, of known age and b.wt. Conventional glass capillary microelectrode recording techniques were used to record focal m.e.p.p.s from preparations bathed in oxygenated Liley saline at a temperature of 32 °C[2,3]. The amplitudes of m.e.p.p.s were corrected for nonlinear-summation[4] and to a standard resting membrane potential (RMP) of −71 mV to facilitate comparison of mean m.e.p.p. amplitudes between groups of rats. The daily restricted diet was always $^1/_2$ of the weight of food eaten by control rats of the same age.

*Results and discussion.* Animals placed on the restricted diet showed a decrease in b.wt for the first 3 days, after which there was an increase in b.wt but at a slower rate than control animals. Because of this loss of weight in comparison with control animals matched according to age, the weight of food per g b.wt. eaten by the experimental animals increased so that it approximated to control values by the end of the first week of dietary restriction. A summary of the results obtained from control rats and from rats placed on the restricted diet for 1 or 3 weeks is given in the table.

1 I would like to thank Dr D. V. Roberts for encouragement and advice and the Medical Research Council and the Muscular Dystrophy Group of Great Britain for financial support.
2 S. S. Kelly and D. V. Roberts, Br. J. Anaesth. *49*, 217 (1977).
3 A. W. Liley, J. Physiol., Lond. *132*, 650 (1956).
4 A. R. Martin, J. Physiol., Lond. *130*, 114 (1955).