This study was performed to determine (1) if electrical slow waves could be recorded from the colon of turkeys, and (2) how ingesta moves into and through the colon despite colonic antiperistalsis. Electrical activity and contractile forces were monitored via implanted bipolar electrodes and strain gage transducers (SGT), respectively. Two types of slow waves, small (sSW) and large (lSW) were recorded simultaneously. The former were correlated with antiperistaltic contractions observed radiographically and with small contractions recorded with SGT, the latter were correlated with large contractions recorded via SGT. The sSW had higher frequencies distally than proximally while the frequency gradient for the lSW was just the opposite. The sSWs were believed to be involved in regulation of antiperistalsis while the lSW were believed to be involved in regulation of the large contractions which, on the basis of the lSW frequency gradient, appeared to be peristaltic and to be primarily responsible for aborad movement of colonic digesta. The small contractions were believed to be responsible for reflux of urine from the cloaca into the colon and ceca and for cecal filling.

Relatively less is known about colonic motility in birds than about motility of the upper portions of the avian gastrointestinal tract. Yasukawa (1) measured colonic intraluminal pressures in chickens using a fluid-filled balloon and Roche et al (2) and Roche (3) have measured electrical potential changes in the colon of chickens with chronically implanted electrodes.

The most striking aspect of avian colonic motility is a continuous orad propagation of muscular activity, ie, antiperistalsis, which involves the entire length of the colon. This has been observed radiographically in chickens (4), turkeys (5), Japanese quail (6), and great-horned owls (7). Yasukawa (1) also observed this phenomenon directly through a plastic window implanted in the side of fowl. He also observed peristalsis associated with defecation. Antiperistalsis apparently moves cloacal urine into the colon and ceca to aid in urinary water reabsorption (4, 8, 9) and, as determined by sacrifice of birds after feeding markers, it also fills the ceca from the more fluid portions of the colonic contents (10–12).

Electric slow waves have not been recorded from the avian colon and colonic contractile forces have not been measured via implanted extraluminal strain gage transducers (SGT). The objectives of this study were, therefore, (1) to attempt to record and to describe electrical slow waves and spike potentials in the colon of turkeys using chronic in vivo preparations, (2) to record contractile activity in the colon and to correlate these events with electrical slow waves and spike potentials, (3) to determine whether slow waves are involved in regulation of colonic motility, (4) to determine the effects of defecation or pentobarbital anesthesia on colonic electrical and contractile activity, and (5) to explain how aborad movements of ingesta from the ileum into the colon can occur despite colonic antiperistalsis.

MATERIALS AND METHODS

Wrolstad medium-white turkeys (Meleagris gallopavo), 6–14 weeks of age and of both sexes were used. Their weights ranged from 1.3 to 3.4 kg. They were fed a
commercial ration (turkey formula 22; nonanimal protein 22%, fat 2%, crude fiber 6%, Land O'Lakes Creameries, Inc., Minneapolis, Minnesota) ad libitum. They were kept in individual cages, had individual feeding and watering pans, and temperature, photoperiod, and humidity of the holding room were automatically controlled. Noise and other disturbances were also controlled and were minimized. Turkeys were fasted for 8–10 hr prior to surgery but were fed normally prior to recording trials or radiographic observations.

Bipolar, Ag/AgCl electrodes and SGTs were prepared for use in turkeys as previously described (13, 14). Sodium pentobarbital anesthesia (40 mg/kg) was used during implantation of electrodes and SGT by aseptic surgical procedures. Turkeys were used in recording experiments beginning at about 7–10 days after surgery in both anesthetized and unanesthetized situations.

In four turkeys, three electrodes were arranged on the colon at approximately 1, 6, and 10 cm from the cloaca in order to record electrical potential changes from areas designated herein as distal, middle, and proximal colon, respectively. In eight other turkeys, two electrodes were implanted on the colon at about 1 and 10 cm orad to the cloaca and two were put on the distal ileum about 2 and 6 cm orad to the ileocecal (ICC) junction. The electrodes implanted on the ileum were used in conjunction with radiographic observations to help determine when emptying of ileal contents into the colon occurred. All electrodes were implanted in an approximate parallel alignment with the circular muscle fibers of the intestine. A reference electrode was permanently implanted in the breast muscle (pectoralis thoracis) of the turkey. In all of the turkeys, two SGTs were sutured to the serosal surface, also in parallel alignment with the circular muscle fibers of the colon, between the implanted electrodes, at approximately 3.5 and 8 cm from the cloaca.

A cannulated fistula was installed at about 14 cm orad to the ICC junction in the ileum of the eight turkeys with ileal electrodes. The fistula allowed injection of BaSO₄ emulsions into the ileum so that emptying of ileal ingesta into the colon could be monitored radiographically. The cannula used in ileal fistulas were formed of polyethylene tubing (ID = 5.28 mm, OD = 6.86 mm). Pieces of this tubing (1.5–2 cm long) were fitted with a saddle-shaped flange 3 mm wide to fit the luminal curvature of the ileum.

The radiographic unit used (Emperor 90/t5 table, 6-in. image intensifier, 875 line split TV, 35-mm cine, Jupiter 900 MA control and transformer, Profexray, Des Plaines, Illinois) consisted of components which allowed both monitoring by closed-circuit television and recording on 35-mm film (double-X negative film, type 5222, DNX 718, Eastman Kodak Co., Oak Brook, Illinois) at a film speed of 10 frames per second. During radiographic studies, turkeys were observed from the right lateral view, either recumbent or standing upright in a cardboard box. When the recumbent position was used, the legs were tied together, the wings were wrapped to the body, and the bird was restricted onto the table to avoid any movement. This restraint did not appear to alter colonic motility. Both methods of observation were performed under normal and anesthetized situations for comparison.

On four occasions, radiographic observations were made during a period of 3–6 hr while simultaneously recording electrical potential changes and contractile forces to correlate events seen radiographically with recorded events. In all radiographic studies, series of short x-ray exposures were used so that no turkey was exposed for more than 2 hr/day, 1 day/week.

The contrast medium (BaSO₄ emulsion, Barosperse, Mallinckrodt Chemical Works, St. Louis, Missouri) was injected into the cloaca or into the ileum through the fistula with a syringe and the tube provided a clear outline of the lumen of the cloaca, colon, and ileum. The ceca became outlined by reflux of BaSO₄ from the colon. It was not possible, without injuring the turkey, to pass the injection tube beyond the ICC junction and into the ileum. However, by filling the ileum with BaSO₄ via the fistula, both ileal emptying and, later, colonic motility could be observed and a longer period of observation of colonic motility was possible than when BaSO₄ was administered cloacally.

The electrical potential changes transmitted from the implanted electrodes were recorded on an 8-channel recorder using four bioelectric amplifiers (recorder model 7788A, amplifier model 8811A, Hewlett-Packard, Wallingford, Connecticut). Time constants of 3.2 and 1.1 sec were used. Contractile forces detected by SGTs were recorded on this recorder using four carrier amplifiers (model 8805B).

Herein the terms peristalsis and antiperistalsis will refer to aborad or orad propagation of muscular activity, respectively. This was observed radiographically or presumed to be occurring when detected successively via a series of implanted electrodes and SGTs. The term flux will be used to refer to intraluminal ingesta movement which was only observed radiographically.

Records were analyzed by 5-min periods; however, portions of records with excessive noise or other artifacts were excluded. To ensure that the electrical potential changes we identified as slow waves were not movement artifacts, records were examined for instances in which (1) our "slow waves" occurred in the absence of contractile activity or, (2) slow waves and their associated contractile activity varied independently in amplitude. The former situation was never clearly seen in our colonic records, whereas the latter was noted in several experiments (eg, Figure 4). Two kinds of slow waves were detected from records of electrical potential changes, viz, large slow waves (LSW) and small slow waves (SSW). Large slow waves were of slightly greater amplitude and considerably longer duration than the small slow waves. Usually, the frequencies and amplitudes of large slow waves and large contractions associated with them were determined using every wave occurring during a 5-min period. The frequency and amplitude of small waves and their associated contractile forces were determined only from activity occurring during the first min of each 5-min period. All electrical and contractile events were analyzed and counted during special events such as defecation and ileal emptying. Student's t tests were used to statistically compare the mean frequencies and amplitudes of electrical and contractile activity recorded from the various implant sites. Action potentials or "spikes" were