EXPERIMENTS WITH THE TERRAGRAPH ON THE ACTIVITIES OF NESTING BIRDS[1]

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THE terragraph is an electro-magnetic instrument for recording the activities of birds and mammals; it was invented by the German Count von Hegendorf[2] and used by him to study the habits of foxes and badgers. I constructed a somewhat similar model, that registered with lines instead of dots.

Although I have made some studies on mammals, I have chiefly used the terragraph to determine the number of feedings per day given the young by birds nesting in cavities, in order primarily to investigate the subject of economic value. Statistics calculated from my results proved the usefulness of our songbirds. With these figures I have been able substantially to further the cause of bird-protection in my home.

Description of the Terragraph. The apparatus consists of a clock with a horizontal disk attachment 19 cm. in diameter which makes one revolution with the clock in each twenty-four hours. On this disk is placed a paper dial-plate marked with hours and half-hours with a carbon paper on top, both being held in place by a tin disk 15 cm. in diameter, which is tightened by means of a central nut.

A telegraph magnet with a pencil attachment is stationed near the disk. When the circuit is made, the pencil presses on the carbon paper, making a short line 4mm. in length on the paper disk beneath (See Figure 3).

The contact at the nest consists of two small pieces of wood fastened together at one end by a flat steel spring. This contact is placed in circuit by means of insulated copper wire with two pocket batteries and the telegraph magnet, so that when a bird alights on the contact the magnet records on the paper disk.

Feeding the Young. The number of feedings in one day in the case of 13 broods of 11 species is shown in Table I. In every instance both parents fed, but with the Pied Flycatcher the male took but little part.

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[1]Translated by Margaret Morse Nice, to whom grateful acknowledgments are due for the suggestion to write this paper for *Bird-Banding*.

[2]Der Terragraph; 1912. Leipzig.

TABLE I

NUMBER OF TIMES YOUNG WERE FED IN ONE DAY

Species	*Number of Young*	*Age in Days*	*Date*	*Number of Feedings*
Green Woodpecker (*Picus viridis*)	3	1	May 11–12	18
		2	May 12–13	17
Wryneck (*Jynx torquilla*)	5	1	June 19–20	141
		2	June 20–21	137
Pied Flycatcher (*Muscicapa hypoleuca*)	5	2	July 11–12	285
Starling I (*Sturnus vulgaris*)	5	3	May 12–13	242
		12	May 23–24	208
Starling II	4	8	May 8–9	107
		11	May 11–12	158
Great Tit I (*Parus major*)	8	4	May 15–16	371
		5	May 16–17	390
Great Tit II	7	10	May 20–21	393
Blue Tit (*Parus cæruleus*)	9	3	May 26–27	350
Nuthatch (*Sitta europæa*)	5	4	May 26–27	370
Tree Creeper (*Certhia brachydactyla*)			June 26–27	152
			June 27–28	78
Song Thrush (*Turdus philomelus*)	5	1	May 26–27	91
		2	May 27–28	142
Redstart (*Phœnicurus phœnicurus*)	5	6	June 8–9	203
Tree Sparrow (*Passer montanus*)	5	2	May 23–24	310
		3	May 24–25	251

With the exception of the Green Woodpecker, the feedings average from once every 12 minutes (Tree Creeper the second day) to once every 2.4 minutes (Great Tit), if we count 15½ hours to the day. The average of the 19 days' records is a feeding once in every 4.1 minutes.

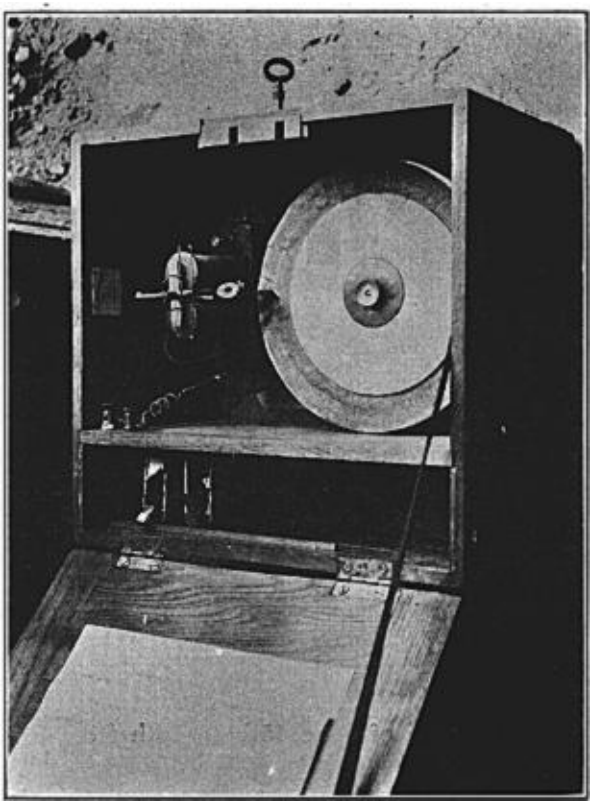

Figure 1. Terragraph in case viewed from above.

In marked contrast to this intense activity is the behavior of *Picus viridis* with only 17 and 18 feedings a day, *i.e.* once in about every 50 minutes. The explanation lies in the fact that this bird feeds by regurgitation. Each feeding lasts from three to five minutes.

An even smaller number of meals was recorded in the case of a pair of Little Owls (*Athene noctua*) with four young 21 days

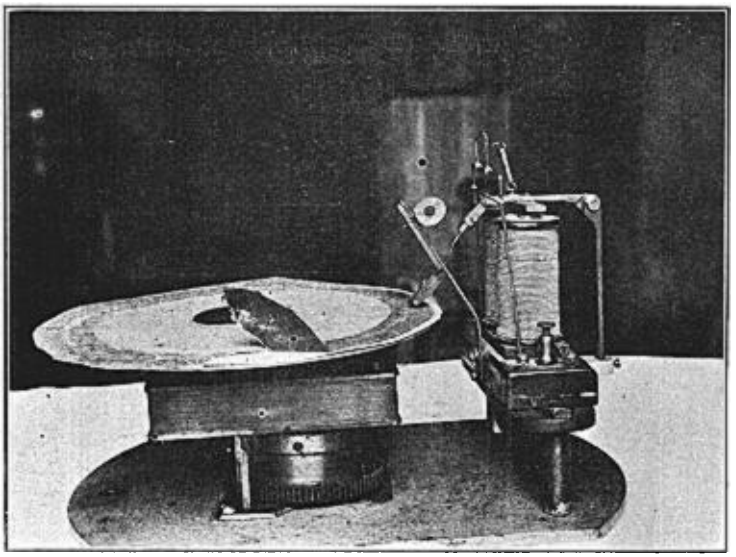

Figure 2. Terragraph removed from case. A piece of the carbon paper lifted to show record below.

old; during the night of June 15th to 16th from 5 P.M. to 3.15 A.M. there were 12 feedings, none being given during the day.

The amount of food brought to the young varies in many cases according to the weather. Starlings and thrushes that depend upon worms, grubs, beetles, etc., have an easier task in wet weather. But birds that capture gnats, crane-flies, and flies fare much better in dry weather. I have known of broods of flycatchers and swallows perishing of hunger after a long spell of rainy weather.

In Table II details are given of the records of three broods, with the number of feedings shown during different periods of the day.

TABLE II

FEEDING OF THREE BROODS DURING DIFFERENT HOURS OF THE DAY

Species	*Weather*	*Date*	*Hours*	*Number of feedings*	*Average Number per hour*	*Total*
Tree Creeper	Warm, but cloudy	June 26–27	4.10– 8.00	53	14.9	
			8.00–10.00	8	4.0	
			10.00– 1.00	31	10.3	
			1.00– 5.00	39	9.8	
			5.00– 8.00	21	7.0	152
	Rainy	June 27–28	4.45– 8.00	8[1]	2.4	
			8.00–10.00	16	8.0	
			10.00– 1.00	17	5.7	
			1.00– 5.00	22	5.5	
			5.00– 8.15	15	4.6	78
Tree Sparrow	Fine	May 23–24	4.40– 8.00	83	24.9	
			8.00–10.00	40	20.0	
			10.00– 1.00	58	19.3	
			1.00– 5.00	71[2]	18.0	
			5.00– 8.15	58	18.0	310
	Fine	May 24–25	4.30– 8.00	34	9.7	
			8.00–10.00	23	11.5	
			10.00– 1.00	52	17.3	
			1.00– 5.00	77	19.2	
			5.00– 8.25	65	19.0	251
Starling	Fine, but cool	May 12–13	4.45– 8.00	68	21.0	
			8.00–10.00	31	15.5	
			10.00– 1.00	33	11.0	
			1.00– 5.00	67	16.8	
			5.00– 8.35	43	12.0	242
	Fine, but warm	May 23–24	4.50– 8.00	55	17.4	
			8.00–10.00	33	16.5	
			10.00– 1.00	46	15.3	
			1.00– 5.00	46[3]	11.7	
			5.00– 7.25	28	11.6	208

With the Tree Creepers there was a period of 80 minutes and with the Tree Sparrows one of 40 minutes in which no feedings were recorded; with the Starlings at one period only 10 meals were brought in an hour and a half. The causes of these interruptions were not known, but observations at other nests have shown that similar irregularities occurred when the

[1]No feeding from 5.05–6.55.
[2]No feeding from 3.30–4.10.
[3]Only 10 feedings from 3.00–4.30.

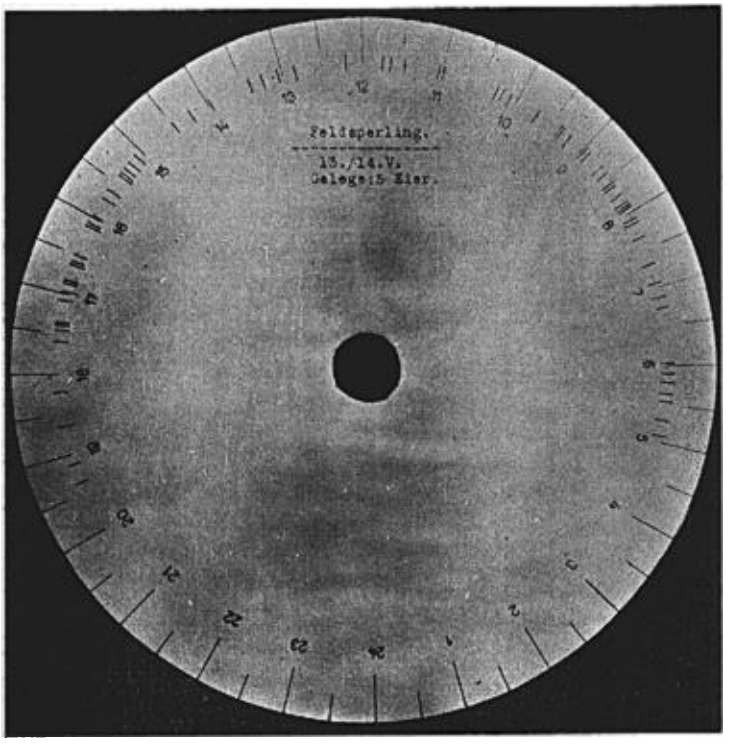

Figure 3. Terragram of a Tree Sparrow's nest during incubation.

parents were frightened by people, Magpies (*Pica pica*), or cats.

If the three periods of disturbance are omitted, the average number of feedings per hour for the different times of day are as follows: 4 A.M to 8.00, 17.1; 8.00 to 10.00, 12.6; 10 to 1.00 P.M., 13; 1.00 to 5.00, 13.7; 5 to 8, 11.4. The most rapid feeding came early in the morning, but a high level was maintained throughout the day with somewhat of a drop towards evening. This rhythm was followed the first day by both the Creepers and the Tree Sparrows and both days by the Starlings, except that the latter during one day fed the least around noon. The Tree Sparrow on the second day fed the least at first and far more from 10 till evening.

Incubation. Records from the terragraph and personal obser-

vations have given interesting results in the matter of incubation, showing that this process is much less intensive in general than has been believed.

A female Wryneck left her eggs as often as 40 times a day; being especially active early in the day and late in the afternoon. Observations with my telescope showed that in this case the female, a banded bird, took sole charge of incubation. A female Redstart left the nest as many as 30 times in a day, often leaving when her mate came to the entrance of the hole, not however that he fed her or assisted with the incubation.

At a box containing four Tree Sparrow eggs on May 10 the terragraph showed much activity. Observation revealed that the male was continually coming to the entrance and enticing the female out. On this day she left 25 times, on the next 30, but on May 12, when the set was complete, 13 times. With this species the male takes some part in incubation.

The most restless sitter of all was a Pied Flycatcher. On May 29 to 30 and 30 to 31 (four days before the eggs hatched) the female left the nest as many as 90 times each day. A constant coming and going took place at the nest-hollow; seldom did the bird sit 10 minutes, and often it was only two minutes before she slipped off to catch a fly, visit with her mate, or attend to her toilet.

At a nest of the Song Thrush the male took no part in incubation nor did he feed the female. On May 18 to 19 the latter left the eggs 21 times, the next day 20. May 20 I watched her behavior with my telescope from 11.00 to ten minutes past 1.00 and found she spent 70 minutes incubating and 60 minutes away from the nest in the following periods—the periods off being enclosed in parentheses: 25 minutes, (10), 10, (5), 35, (45). Five days later I watched from 12.00 to 5.30; the total times spent on the nest was 200 minutes, off 130. The weather was fine on both days and approximately the same temperature—80° F. On this day her periods both on and off averaged much longer than on May 20: (70), 80, (35), 90, (15), 20, (10), 10. At 5.25 the first egg hatched, the second at 6.15, the third at 6.50, while the other two young were out early the next morning.

The great Black Woodpecker (*Dryocopus martius*), a rare bird that digs its home in a living tree, was found by personal observation on two nests to have a very regular schedule in the matter of incubation. The female incubates from about 5 P.M. to 7 A.M., the male from 7 to 11, the female from 11 to 2, and the male again from 2 to 5.

Sleeping Habits of Woodpeckers. During one winter I in-

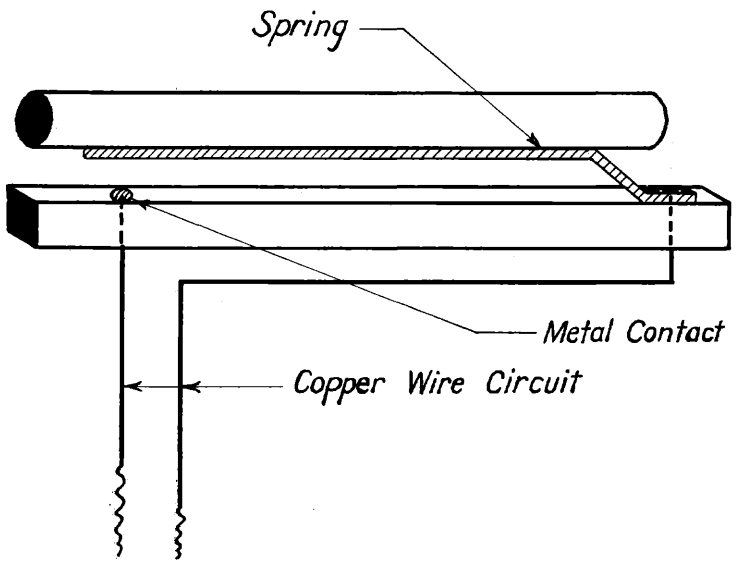

Figure 4. Diagram of Electric Contact at Nest.

stalled the terragraph in a beech wood where five holes of the Black Woodpecker were used by individuals of this species and also of the Green Woodpecker and Gray Woodpecker (*Picus canus*). There was considerable quarrelling over the sleeping-quarters; sometimes a bird would leave its hole to chase off an intruder, only to have a third individual slip in and refuse to be dislodged. On November 20 the terragraph showed that the hole was occupied from 5.15 P.M. to 7.35 A.M.; while the next afternoon, which happened to be cloudy, a bird entered at 4.50 and did not leave till 7.50 the next morning.

Accounts of all these and other observations have been published in Switzerland in *Der Ornithologische Beobachter*[2] and *Mittelschule*.[3]

[2]Vol. 21, pp. 17–20, 168–170; Vol. 22, pp. 77–78, 157–158; Vol. 25, pp. 22–25; Vol. 27. 17–21; Vol. 28, pp. 151–155; Vol. 29, pp. 129–130, 153–156.
[3]Vol. 11, No. 2; Vol. 14, No. 5; Vol. 15, No. 6.