*AN AUTOMATIC PELLET DISPENSER FOR PRECISE
CONTROL OF FEEDING TOPOGRAPHY IN
GRANIVOROUS BIRDS*

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Design and construction of an automatic pellet dispenser for granivorous birds are described. The dispenser permits rapid pneumatic delivery of pellets (five pellets per second maximum) to one controlled position and does not interfere with simultaneous electrophysiological recording. In addition, the device continuously indicates presence or absence of a pellet in the delivery position. This automatic dispenser proved very effective in our studies of stereotyped topographies of feeding in granivorous birds, such as pigeons and chickens.

Key words: feeding, pecking, birds, pigeons, chickens

Most granivorous birds adapt their ingestive behavior to various intrinsic aspects of the food, including type, size, shape, color, texture, and taste (Berkhoudt, 1985; Bermejo, Houben, Allan, Deich, & Zeigler, 1987; Zeigler, Levitt, & Levine, 1980; Zweers, 1982, 1985). One obvious contributor to variability in the topography of feeding is the three-dimensional location of the food. In the pigeon, for instance, body orientation, head motion, and jaw movements all change in response to different seed positions (Zweers, 1982, 1985). To minimize variability when studying the stereotypy of feeding in granivorous birds, identical food particles must be delivered precisely to a single spot.

Although various commercial pellet dispensers exist, for instance in combination with operant test chambers of different brands (Gerbrands; Lehigh Valley; Coulburn), such feeders are very slow and do not dispense to a precisely controlled position. Our research involving EMG and high-speed filming required a device that did not have those limitations, so we designed the pellet dispenser that is described here. The device is unique in its speed, and it is adaptable to different pellet sizes with slight modification. It is well suited for studies of reinforcer magnitude because the delivery system does not require a confounding of reinforcer duration, number, and size as is the case with the standard grain hopper. The device also satisfies some additional criteria:

1. The speed of pellet delivery accommodates the maximal intake rate of a bird, permitting normal, undisturbed feeding patterns and, secondarily, allows optimal use of high-speed film.
2. Pellets are presented at floor level, which permits a feeding topography comparable with that of natural situations.
3. Pellet delivery does not interfere with sensitive electrophysiological recording techniques nor with delicate magnetorestrictive measurements used in gape-width recording (see Deich, Houben, Allan, & Zeigler, 1985).
4. An output voltage is provided that signals presence or absence of a pellet at floor level.

GENERAL FEATURES

The purpose of the pellet dispenser is to present food, either peas (7.8 mm diameter) or dust-free precision pellets for pigeons (6.8 mm diameter) as single items. After removal of the presented pellet by the bird, the next pellet is immediately supplied. Maximum delivery speed is about five pellets per second. Both pellet delivery and loading of the supply are pneumatically driven. Compressed air lifts the pellet-delivery piston (identified as P in Figure 1), with the pellet on top of an adaptor (Figure 1E) to the bird's floor level. On removal of the positive air pressure (by a switch valve; Figure 1C) the piston retracts by coil-spring action, so that the adaptor surface is just under the opening of the supply tube. The spring around the piston rod serves two pur-

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Fig. 1. Mechanical design of pellet dispenser. A, platform; B, protective housing; C, microswitch; D, small piston, moving pellet supply; E, top adaptor of pellet-delivery piston; F, pellet-supply tube; P, pellet-delivery piston.

poses: (a) to decrease the acceleration when the piston and attached pellet-delivery adaptor is moving upward and (b) to move the piston down to allow loading of the next pellet. The pellet-supply tube was made long enough to accommodate approximately 18 pellets, a supply sufficient to last one exposure of low-speed film (about 3 s at 64 frames per second). A suction of 0.5 bar, generated by a compressor from a refrigerator (any vacuum pump delivering 0.5 bar will do) is supplied to a hole in the adaptor, for two functions: (a) To keep the pellet in position on top of the pellet delivery adaptor; when the piston is accelerating upwards, the suction also ensures that the pellet is not ejected beyond the floor level and (b) To detect the presence or removal of a pellet in the delivery position, a monolithic pressure sensor (Philips, KP101A; shown in Figures 1 and 2) is shunt-mounted on the suction tube and electronically operates the switch valve. A sufficiently large negative pressure caused by a pellet in position (adjustable by means of R5) has to be present in the tube to issue the "piston up" and "pellet still present" command. To transport the next pellet from the supply tube to the top of the piston, a pulse of air, generated when the piston is pushed down by the spring, is used. This pulse gently pushes

the next pellet of the remaining supply into delivery position. This operation is facilitated by a small, easily moving piston positioned behind the pellet supply (Figure 1D).

MECHANICAL DESIGN

The structural base of the pellet dispenser is a platform (Figure 1A) made from 12-mm thick PVC, which can be used in two different experimental applications. It can be mounted to form the floor of a filming cage (45 by 15 by 40 cm), positioned inside a larger (e.g., electrically shielded) cage, which the bird must enter before it has access to the food supply. Or, it can form the floor of a filming area (14.5 by 8.5 by 40 cm), in which only the bird's head and rostral neck are exposed, attached to an operant conditioning chamber (40 by 40 by 40 cm). In both applications a grid of 1-cm squares, either black on white or white on grey (depending on the contrast with the individual bird), is used to facilitate measurement.

All mechanical components are mounted on the platform. The pellet-delivery piston (6 mm in diameter, 20 mm long; in microcylinder 10; Universo S.A. UVC 6/20 F, La Chaux de Fonds, Switzerland) (Figure 1P) is contained in a protective PVC housing (Figure 1B). Also

Fig. 2. Schematics of the electronic design of the pellet dispenser control unit.

mounted within this housing are the pressure transducer and a microswitch (Figure 1C) that detects the position of the pellet-delivery piston.

The inlets for suction (0.5 bar) and compressed air (1.5–2 bar) lines and a connector (Lemo SA, Morges, Switzerland) for connecting the microswitch and pressure transducer with a control unit are positioned on the exterior. Mounted under the platform is a transparent plexiglas supply tube (12 by 8.5 mm diameter) in which the pellet supply is contained; its length determines the maximum number of pellets that can be dispensed without reloading. The pellet-delivery adaptor is mounted perpendicularly to the outlet end of this supply tube; at the opposite end an inlet socket is situated for delivery of compressed air. The total pellet supply is moved towards the delivery adaptor by a small piston (8.5 mm diameter; Figure 1D) made of Delrin. This

piston is made to fit snugly in the tube by use of an O-ring.

Before the supply tube can be reloaded, the small piston moving the pellet supply has to be in fully retracted position by pulling a thin (0.3 mm diameter) nylon string that passes through a small hole punched in the nylon air tubing (6 mm diameter). Then the complete air inlet socket-piston combination can be disengaged as one unit. The diameter of the pellet-delivery adaptor, made of PVC, is kept as small as possible (9 mm), only slightly larger than the pellets. In the middle of its top a 2.9-mm hole is drilled, accommodating a piece of silicon rubber tubing (3 mm diameter), which is connected to the pressure transducer and further on with a vacuum pump (compressor from refrigerator; as noted previously, any vacuum pump giving 0.5 bar or less will do). This tubing ensures that the pellets are kept properly on top of the pellet-delivery adaptor, so

that the pellets are not "launched" during the rapid acceleration of the upward moving piston. Only the top adaptor, the supply tube, and its piston need modification for different pellet sizes.

Technical Specifications

The air pressure needed for proper pellet delivery is between 1.5 and 2 bar (21.3 and 28.4 psi). A vacuum, sufficient to keep the pellets attached on top of the piston, is 0.5 bar (7.1 psi).

ELECTRONIC DESIGN

In an earlier version of the pellet dispenser, the presence or absence of the pellet was detected by an infrared reflex sensor (F106-109). This sensor, oriented upwards, was incorporated in the center of the top of the pellet-delivery adaptor, and the suction tube was positioned off-center at the camera side. This system had several drawbacks. First, the pellet could activate the reflex sensor before it had adhered to the suction tube. Usually this was caused by irregularities in pellet shape. The result was "launching" of the pellet. Second, in case of excessive extraneous light sources (spotlights used in high-speed filming or even sunlight), false infrared information via the reflex sensor was sent to the electronics, resulting in oscillations of the piston.

The monolithic pressure sensor, which is presently used for pellet detection, consists of strain gauges together forming a Wheatstone bridge (see also Philips doc. on type KP101A). By means of a differential preamplifier, followed by a second amplifier, in which the offset can be adjusted (switching point at a given negative pressure), the signal from the pressure sensor is sufficiently amplified and filtered

from the AC line frequency (C1, C2) to activate the LED marked "sensor." This signal is fed into a comparator/Schmitt trigger, which serves to introduce hysteresis in the system, to eliminate oscillations in the switch valve. This valve is controlled by way of a Darlington power transistor (Texas Instruments type 2N 6388; T1 in Figure 2).

By means of an AND-function of the pressure sensor and a microswitch (MS1), status information is present at the recorder output (REC. out.), signaling whether a pellet is present on top of the pellet-delivery adaptor at floor level (+0.7 V) or not (0 V). A manual override button is a useful extra feature to lift the piston for cleaning or for single-pellet delivery.

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