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USE OF AN ELECTRONIC BALANCE WITH BANK SWALLOW NESTS: A NEW FIELD TECHNIQUE

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Abstract—Weighing nests with balances during the nestling-feeding period may provide the basic information on foraging characteristics. In this paper a technique is presented for the installation of electronic balances at nests of the hole-nesting Bank Swallow (*Riparia riparia*), a typical colonial breeder. Nest materials with nestlings were dug out and placed in a specially

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designed nest box (Fig. 1a), called a Riparibox. The Riparibox was settled on an electronic balance in the pit (Fig. 1b). The electronic balance was connected by cables to an IBM PC/AT-compatible laptop computer, using serial interfaces (RS-232C) for data transmission. For data acquisition and preprocessing, a special program package (NestBug), which was developed for the automated observation of nests using electronic balances, was used. With this system, continuous measurements of parental body mass and load size were made at two nests over 5 d. The time spent by the Bank Swallow on the balance was long enough to get precise body-mass measurements. The preliminary analyses of data showed a significant increase in body mass and decrease in load size with time of day. These relations may indicate growing investment in self-maintenance relative to investment in offspring during the day.

EL USO DE UNA BALANZA ELECTRÓNICA EN NIDOS DE *RIPARIA RIPARIA*: UNA NUEVA TÉCNICA DE CAMPO

Sinopsis.—El uso de balanzas para pesar el nido durante el período de alimentación de los pichones puede proveer de información básica sobre las características de forrajeo. En este trabajo se presenta una técnica para instalar balanzas electrónicas en nidos de la golondrina *Riparia riparia*, la cual anida en cavidades de forma colonial. Se removieron nidos seleccionados con pichones y se colocaron en cajas especialmente diseñadas (Fig. 1a) y que llamamos riparicajas. Las riparicajas fueron colocadas sobre una balanza electrónica (Fig.1b). La balanza a su vez fue conectada con cables a una computadora portátil IBM PC/AT, utilizando interfases de serie (RS-232C) para la transmisión de los datos. Para la adquisición y pre-procesamiento de los datos utilizamos el programa NestBug, que fue diseñado para la observación automática de nidos utilizando balanzas electrónicas. Con este sistema se tomaron medidas continuas, en dos nidos por un período mayor a 5 días, sobre la masa corporal de los adultos y el tamaño de la carga que llevaron a los nidos. El tiempo que los adultos pasaron posados sobre la balanza permitió tomar medidas precisas sobre su masa corporal. El análisis preliminar de los datos, muestra un aumento significativo en la masa corporal y un decrecimiento en el tamaño de la carga llevada al nido con el pasar del día. Estas relaciones parecen indicar un aumento en la inversión para su propio mantenimiento por parte de los adultos en relación a la inversión hacia los pichones a través del día.

Many studies show the important role of foraging in the evolution of colonial breeding in birds (Barta and Szép 1992, Ward and Zahavi 1973). In the case of the Bank Swallow (*Riparia riparia*), which is a typical colonial species, measuring foraging parameters for long periods at some nests may help to investigate the role of foraging in coloniality. Previous methods (e.g., neck collars on nestlings, visual observation) could reveal some basic characteristics of foraging (Bryant and Turner 1982, Stuchbury 1988), but these techniques could only provide a restricted set of estimates and they are not appropriate for long, continuous observations. Weighing nests with balances during the nestling-feeding period may provide the necessary information on foraging characteristics, as Jones (1987a, b, c) showed in his studies of Barn Swallows (*Hirundo rustica*). Moreover, electronic balances allow the use of computers for data recording, which makes long-term observations possible. This approach was used recently in studies of Swifts (*Apus apus*) (Martins and Wright 1993) and of hole-nesting birds (flycatchers and tits; Tóth et al. unpubl. data). Unfortunately, the breeding mode of Bank Swallows, nesting in holes in bank walls, makes the use of balances difficult.

In this paper we present a technique for the installation of electronic balances at Bank Swallow nests and report some initial results.

METHODS

The study was carried out at a Bank Swallow colony along the Tisza river in Eastern Hungary (Szép 1991), close to Szabolcs village (48°11′N, 21°31′E). The colony consisted of 69 active nests. The two nests studied were situated in the center of the colony. Each of them contained five eggs and were in the main synchrony group (Emlen and Demong 1975). We banded one of the parents at each nest and we marked each on the primaries with white Pelican Blanco correcting fluid for further visual identification. We prepared the nests for the balance on 3 June when the nestlings were 7 d. There were five nestlings in nest 1 and three in nest 2. Measurements were started on 6 June when the nestlings were 10 d old. We collected mass data from sunrise to sunset (0500–2100 hours). We finished the study on 10 June when the nestlings were 14 d old. At this time accurate measurement in some cases was confused by the increased activity of growing nestlings.

After receiving permission from the local nature conservation agency (Hortobágy National Park) and practicing on old and unused nests we proceeded to install the balances. We dug out the chosen nests and placed the nest materials with nestlings in a specially designed nest box (Fig. 1a), which we called a Riparibox. We discovered the positions of neighboring nests and plant roots to avoid destruction of other nests. First, a hole was dug to the nest at an angle from behind, with continuous control of nest and nestling by fiberglass, then nest and nestlings were removed. Next, a pit was dig down to the nest from above. The Riparibox was settled on an electronic balance in the pit (Fig. 1b). The body of the Riparibox was made of plywood, and we applied a plastic tube as an entrance channel. We used a quite long channel to prolong the stay of feeding birds on the balance. We put another plastic tube in the swallow-made channel to ensure a good junction with the Riparibox. There was a tiny (2–3 mm) gap between the ends of the two tubes. The pit was covered by a plywood sheet, in turn covered by a thin layer of soil to protect the balance and the Riparibox from light and water. We checked the Riparibox every second day.

We used Mettler PM4600 balances (4100-g capacity, 0.01-g accuracy, Mettler-Toledo AG, Greifensee, Switzerland) connected by cables to an IBM PC/AT-compatible laptop computer, using serial interfaces (RS-232C) for data transmission. These balances can produce eight weighing results per second, providing a good resolution in time. The computer was situated in a blind, 50 m from the nests.

For data acquisition and preprocessing we used the NestBug program package (available from Z. Tóth; see Appendix), which was developed for the automated observation of nests using electronic balances. This software was used on hole nesting passerines breeding in artificial nest boxes (Z. Tóth, unpubl. data). The software consists of two modules. The first module (Data Acquisition Module, 2.5) performed data recording on the field. It recognized mass changes of the nest as events if they were greater

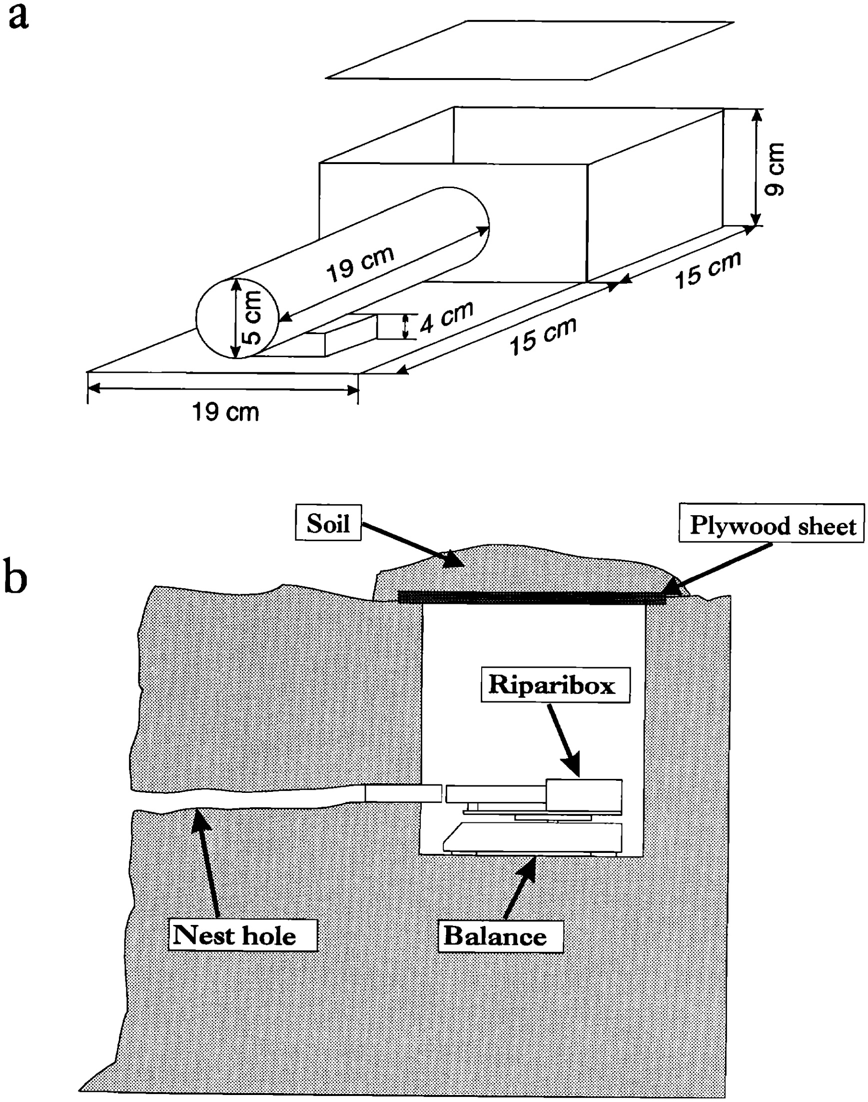

FIGURE 1. a. The structure of Riparibox. b. Settlement of Riparibox and balance in the bank wall. The distance between the two plastic tubes is 2–3 mm.

than a selectable sensitivity value, and stored pre-event and post-event weighing series with the exact time of the event. This technique prevented us from storing large amounts of irrelevant data (e.g., the changes caused by moving nestlings). We used 7 g as sensitivity value, which is about half of the parent's body mass.

The mass changes of the Riparibox due to the parent's visits were calculated from data series by the second module of the software (Visit Analyzer Module 0.5). The body of the feeding bird was computed as the difference between the mass of the Riparibox with parent and the mass of Riparibox immediately after the parent left. NestBug determined the load size as the difference of the mass of the Riparibox immediately after parent's leaving and before its arriving. Finally, the program produced a list of the visits showing the body mass, load size and time. The staying time of the parents was defined as the elapsed time from arriving to leaving. To exclude rare, very short visits(2–3 s), simultaneous visit of parents and the nestlings' walking out of and into the Riparibox, we checked manually the list produced by NestBug. As Bank Swallows carry out the nestlings' feces, which is usually heavier than the carried load, we found load sizes below zero, which were also excluded from the analyses. The direct observation of leaving birds confirmed this relation (in 41 cases of 48 observed feces carrying (85.4%) the load size was below zero).

We observed directly the two nests from a blind to check the data produced by the system. We recorded sex of the leaving parents, time of leaving and presence of feces carrying. Furthermore, using binoculars, we observed the behavior of the focal and nearby birds to examine the potential effects of the applied technique.

Data for all days were pooled in the analyses. Analysis of covariance (ANCOVA) was used to examine differences among the individuals (Sokal and Rohlf 1981), with arrival time and parents' body mass as covariates.

RESULTS

We did not find any negative effects of using the Riparibox on the behavior of parents and nestlings. The adult birds accepted the Riparibox within 30 min. We did not observe the parents hesitating to enter the hole or staying less time in the nest than other birds. Their behavior did not differ in any way from that of other birds in the colony. All visually observed visits were recorded by our system. We could distinguish the visits of parents from the movements of nestlings by the characteristics of the weighing data.

The average time in the nest was 29.24 s (SD = 54.95; n = 901), which was long enough for precise weighing. This precision was confirmed by the low average standard deviation of the masses measured during the parents' visits (e.g., average SD = 0.0681 g, n = 138 for 10 June at nest 1).

The body mass of the breeding birds increased during the day (Fig. 2), as shown by regression analyses (Table 2). The body masses significantly varied between sexes and nests (Table 1, two-way ANCOVA, $P < 0.001$; mass was corrected for arriving time). These differences in body masses allowed us to distinguish the sexes at the same nest if the difference between them was greater than 0.5 g, which was the maximum value of the difference in body mass of an individual between two consecutive visits. On the first 2 d the difference between the two parents did not

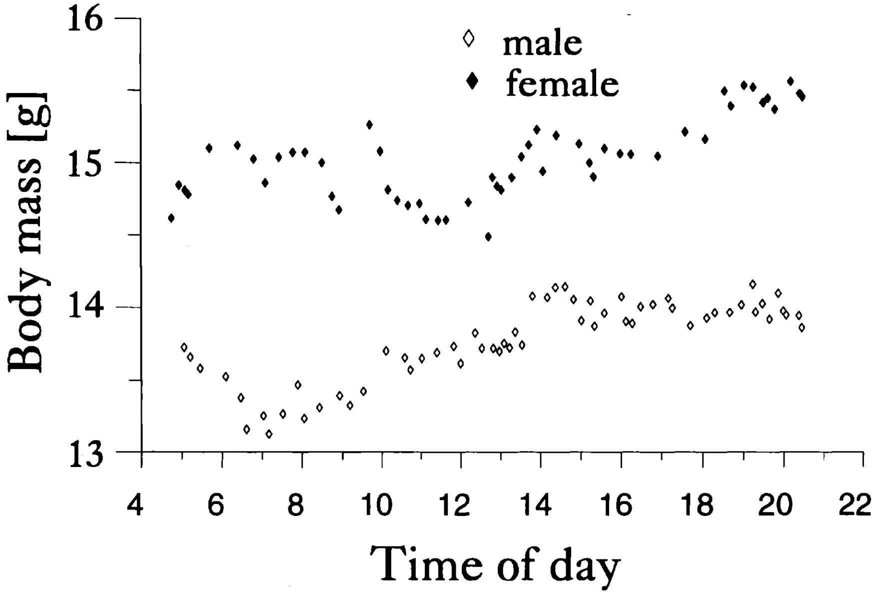

FIGURE 2. Changes of body mass of both sexes over a typical day. All visits with reliable body mass measurement are included (nest 1, 10 Jun. 1992).

exceed 0.5 g at nest 2, but we were able to identify the sexes using our direct observation.

The sizes of loads carried by the parents decreased during the day (Fig. 3), as shown by regression analyses (Table 3). The load size significantly differed between sexes (Table 1, two-way ANCOVA, $P < 0.001$, load size corrected for arriving time).

DISCUSSION

In this study we were able to use electronic balances to measure continuously parental body mass and load size at two nests of the hole-nesting Bank Swallow, over 5 d. The Riparibox and installation technique appeared not to disturb the birds, and therefore, may be suitable for

TABLE 1. The average body mass and load size of the studied individuals during the observation. Reliable mass measurements of identified individuals only were included. (Data for all days were pooled.)

Nest	Sex	Body mass ± SD [g]	*n*	Load size ± SD [g]	*n*
1	Male	13.9090 ± 0.3252	210	0.1781 ± 0.0800	209
1	Female	14.9935 ± 0.3420	175	0.1438 ± 0.0769	175
2	Male	13.5082 ± 0.3422	165	0.1698 ± 0.0870	165
2	Female	13.1072 ± 0.3152	182	0.1522 ± 0.0597	182

TABLE 2. The linear regression of body mass with arrival time for the studied individuals. Reliable mass measurements of identified individuals only were included. In two cases the precise arrival time could not be determined due to walking nestlings, therefore these data were excluded. (Data for all days were pooled.)

Nest	Sex	*r*	*n*	Slope	Intercept
1	Male	0.659*	208	0.0493	13.24
1	Female	0.593*	175	0.0445	14.41
2	Male	0.785*	165	0.0589	12.76
2	Female	0.760*	182	0.0536	12.33

* $P < 0.001$.

measuring foraging parameters. The computerized data recording system (NestBug) can monitor parental activity, body mass and load size over several days. It was necessary, however to check manually these results because of the movements of nestlings, small mass difference between the sexes and inaccurate weighing due to short staying time. To have reliable individual identification one needs some direct visual observations of visits during the day. Feces carrying was inferred from calculated negative load size.

The time spent by the Bank Swallow on the balance is long enough to get precise body mass measurements. The preliminary analyses of data showed a significant increase in body mass and decrease in load size with

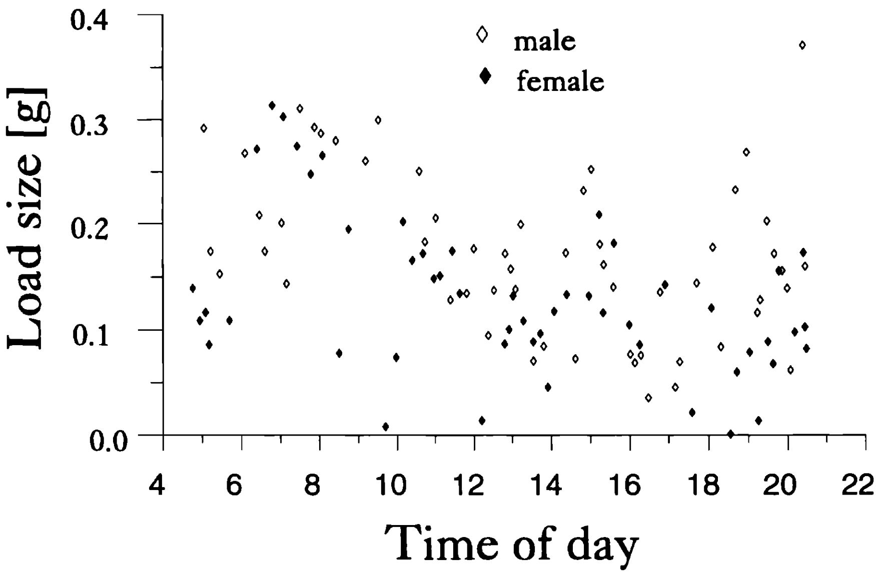

FIGURE 3. Load size carried by both sexes over a typical day. All visits with valid load size measurement are included (nest 1, 10 Jun. 1992).

TABLE 3. The linear regression of load size on arrival time for the studied individuals. Reliable mass measurements of identified individuals only were included. In two cases the precise arrival time could not be determined due to walking nestlings, therefore these data were excluded. (Data for all days were pooled.)

Nest	Sex	*r*	*n*	Slope	Intercept
1	Male	0.202**	208	−0.0054	0.2576
1	Female	0.161*	175	−0.0027	0.1795
2	Male	0.286***	165	−0.0055	0.2393
2	Female	0.350***	182	−0.0046	0.2201

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

time of day. These relations may indicate growing investment in self-maintenance relative to investment in offspring during the day.

This on-line measuring system may stimulate a new type of investigation to study the role of foraging in the colonial behavior of Bank Swallows.

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APPENDIX

NestBug is an on-line data recording and data processing software package for IBM PCs, employing electronic balances as bugging devices to gather data on parental activity, parental condition and load mass. NestBug consists of two main program modules, the Data Acquisition Module and the Visit Analyzer Module, and their documentation files. By measuring nest mass continuously, the system provides the following information about each visit to the nest: (1) identity of visitor (heavier vs. lighter parent); (2) time of arrival and of departure (feeding frequency); (3) foraging time and feeding time; (4) mass of the visitor (and change since its last visit); (5) load mass (except when feces taken out); (6) some additional information, e,g. nest mass before and after visit. All are calculated automatically, with optional user control. The software can also be applied to the weighing of perches, feeders or other objects visited by individual birds.

Data Acquisition Module

The data acquistion program can handle up to four Mettler and Sartorius balances depending on the number of serial ports present in the PC, and has a simple, easy-to-use user interface.

Main features.—Receives weighing results (6–10/s/balance), selects them on the basis of event recognition and stores the resulting raw data on disk (pre-event and post-event mass series; time). Both single and simultaneous visits are recognized. Non-stop measuring sessions can extend over days without user control.

Additional features.—(1) Displays: actual mass, time of events, approximate mass of visiting bird and of load, visit counter, messages and status information for each nest separately. (2) User options: suspend observation of any nest, tare balance, specific signal sounds on events, nestling weighing (manually at nest, masses stored by NestBug). User can enter remarks during observation, which are time labeled and stored on disk. (3) Safety functions: update disk files every 30 min; message, alarm sound and note to log file in case of emergency (i.e., abnormal mass changes, data flow errors).

Disk output.—Data file/nest, remarks file and log file. All files are in ASCII format.

Visit Analyzer Module

The visit analyzer program converts recorded raw data into a tabular format file that contains the above listed variables for each visit. Totals (counts, averages) are written to a separate file and optional files may be created with periodical subtotals throughout a day. Data conversion involves several processes: find the right mass level out of a recorded weighing result series omitting "outlying" values (fluctuations), then calculate visitor's mass at arrival and departure and load mass. The program identifies "female" and "male" visits by sorting visitor masses into two groups

(0.2–0.4 g difference can be sufficient for 10–20-g birds), and can cope with simultaneous visits. The program then can calculate foraging and feeding time intervals. Problematic, ambiguous cases get marked. All these calculations are performed in seconds for a whole nest-day (up to hundreds of visits), and the program also provides user control over the process. Control is supported by graphs that present: (1) the recorded weighing result series (with omissions) and (2) the masses of loads and parents for a nest-day (with identification of parents and time-proportional zoom and scroll). Total control is assured by an intermediate data file that lists each event giving its time and the respective mass-change value, and ultimately by the recorded raw data. The Visit Analyzer Module has a graphical user interface with mouse-driven menus.

Hardware Requirements

- IBM PC/AT compatible machine with 1–4 serial ports, MS-DOS operating system.
- Electronic balances with serial data interface (RS232C). Mettler series: PM, PB, PJ, BasBal, College. Sartorius series: LC, BA, PT. Prices range approximately $600–2000 (U.S.).
- Data transmission via radio waves or cable. Using 3 × 0.75 mm, not-shielded cables (the kind used for AC power distribution; approximately $0.35/m in Hungary) we have not yet experienced a length limit: 500–600 m was no problem.
- Power consumption: well under 100 VA for a portable PC (Laptop, Notebook) and four balances. Either AC or DC (local battery) can be used.
- Installing the balance we use a bigger box that surrounds the balance and weighed nest box to prevent wind-effect and false visits.

Future features.—More than four balances handled by one PC; local data recording by palmtop (hand-held) computers; increased flexibility, configurable setup; output signals on certain events to control additional devices (e.g., siren, camera); more graphing power (e.g., distribution graphs, hard copy).

NestBug is available for the purpose of non-profit research work, provisionally free of charge. If you are interested, please contact the developer.

License Agreement

NestBug Package I includes version 3.0 of the Data Acquistion Module and version 0.6 of the Visit Analyzer Module.

Terms of Use

1. NestBug is provided "as it is" without any warranty.
2. NestBug is distributed free of charge, provisionally.
3. The developer reserves all rights to NestBug.
4. NestBug is licensed for non-profit research work, provided that the

following conditions are satisfied. (a) The completed Registration Form is returned to the developer. (b) The program is used exclusively by the registered user(s) and his/her direct colleagues who are working together on the same project. The program is used in its original form, with its copyright notice left intact, exclusively in non-profit research work, i.e., for collecting and analyzing biological data. (c) If data collected and/or analyzed by NestBug become a part of a publication or a report of any sort, the program and its developer are named in it until the developer specifies a reference paper to be cited. (d) The developer receives a copy of any written publications or reports, specified under 2. c., from the authors. (If only a fraction of a large report is related to the application of NestBug, then the copy may be restricted to the respective section[s].) The developer uses these preprints, reprints or reports for documentation of the use and the capabilities of NestBug (e.g., when applying for financial support, or advertising the software).

5. Registered users who respond to the request list below within 1 yr of registration will receive information about future releases and free technical support via e-mail.

Requests to the User

Please supply the developer with any relevant informatin that can be used for the improvement of NestBug, and its application, such as: (1) experiences in using the programs and their documentation (errors, confusion, demands, ideas, comments, suggestions); (2) experiences concerning the hardware elements (balance models, installation of balance in the field, data transfer solutions, computers, power supply solutions); (3) experiences in the fieldwork, about the balance and the birds. The developer is also ready to share such experiences with the user.

The developer would greatly appreciate reprints that report NestBug observations or references describing similar measuring techniques.

Please give developer's address (Zoltán Tóth, Population Biology Group, Department of Genetics, Eötvös University, Muzeum krt. 4/A, 1088 Budapest, Hungary. Telefax: 36-1-266-2694. Telephone: 36-1-266-1296) or the License Agreement to persons who show interest in NestBug. The preferred method of shipping is via e-mail (Internet: tothz@ludens.elte.hu).