ARTIFICIAL NEST SYSTEM
on Ardery Island, Antarctica

An automatic weigh- and identification system for birds developed by the Institute for Forestry and Nature Research (IBN-DLO), The Netherlands

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1. Introduction

The Ardery Island artificial nest system has been developed to record weight changes of birds on their nests and to identify the birds on their nests. After try-outs in The Netherlands the system has been operational on Ardery Island, Antarctica, since October 1996. Data obtained from the nest system is used for a long-term study on the breeding and foraging ecology of two species of petrels (Antarctic petrels *Thalassoica antarctica* and Southern fulmars *Fulmarus glacialoides*) breeding on the island.

The artificial nest-system on Ardery Island is especially designed for research on petrels in Antarctica, but it could be used in any other environment and with any bird species. It has low power requirements and functions in extremely variable weather conditions.

The artificial nests are placed on the actual nest location and petrels are so strongly attached to their nest sites that they easily accept them as their new homes. The breeding success of the birds on artificial nests is equal to the breeding success of birds on natural nest sites.

In the three seasons of 1996/97, 1997/98 and 1998/99 there has been 30 to 45 artificial nests operational each year in two study colonies on the island.

This text is written for biologists, technicians and other people interested in the Ardery Island artificial nest system. First we will give some background information on the Ardery Island project and the development of the artificial nest system. Then we will describe the various elements of the artificial nest system and how they work. The following chapter will describe the software and explain which data are obtained. The last chapter shows some results and how the data can be used.

This text is meant as a short introduction to the artificial nest system on Ardery. For more detailed information please refer to the addresses at the end of this paper.

2. History of the Ardery Island artificial nest system

The development of the artificial nest-system was started by Jan van Franeker of the Institute for Forestry and Nature Research in The Netherlands (in Dutch: Instituut voor Bos- en Natuuronderzoek, abbreviated to: IBN-DLO). Jan van Franeker has worked on petrels and other seabirds since the early eighties and visited Ardery Island four times since 1984. In 1996 he started a long-term research project on fulmarine petrels on Ardery Island. This long term project was funded by the Netherlands AntArtic Programme (NAAP).

The main person behind the development of the hardware and the software of the nest system is Willem van der Veer of the Technical Department of the IBN-DLO. He designed the nest system in close cooperation with Jan van Franeker. The development began in 1994.

Willem is a technician at the Technical Department of IBN-DLO. He gained experience with developing a weigh system for an earlier project of the IBN-DLO on geese in Siberia. Also, he developed identification systems for various animals in The Netherlands.

Much time was spent in Holland testing and improving the artificial nest system before trying it out in Antarctica. When the artificial nests became operational for the first time on Ardery Island, Willem stayed 4 months on the island to help with the installation and to instruct the biologists on the operation of the system. Since 1996 the system has been "fine tuned" to the local situation using new suggestions from the field workers in Antarctica. New features have been added and more functions in the software have been implemented.

Jeroen Creuwels from IBN-DLO/University of Groningen, The Netherlands has spent three seasons on Ardery Island since 1996, and used the artificial nest system for his Ph.D. project on Antarctic petrels and Southern fulmars. His supervisor is Jan van Franeker.

In the last two seasons Jeroen had two technical assistants to assist him. In the 1997/98 season this was Jeroen Hasperhoven, an electronic engineer just graduated from the University of Enschede. In the 1998/99 season Waldo Ruiterman, a student of Electronic engineering at the Polytechnic of Groningen, provided technical assistance. Their technical knowledge and experience in the field was used by Willem van der Veer to improve the system.

Fig 1. Overview of the field camp on Ardery Island. Energy is supplied by a wind generator and solar panels. The two study colonies with the artificial nests are 500 and 800 m away from the field camp.

3. Artificial nest-system elements

The system on Ardery Island consists of various elements such as:

- a network of artificial nests,
- alternative energy systems to supply power in the bird colonies and to the logger computer,
- a web of short data- and power-cables to connect the artificial nests in the field,
- data cables from the study colonies to the logger computer in the field hut,
- a logger computer in the field hut
- software to manage the artificial nest system.

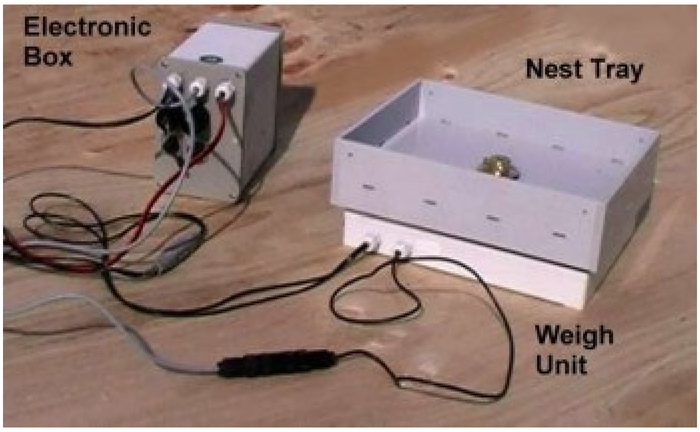


Fig. 2. Overview of the various elements of an artificial nest

As is shown in Fig. 2 each artificial nest consists of three parts:

- *Nest unit*, this is a waterproof plastic box in which a load cell for weighing and an antenna for identification is located.
- *Nest tray*, a plastic 'plate' which is located above the nest unit on top of the pin of the load cell. The birds sit on this plate.
- *Electronic box*, this box contains all the electronic equipment for identifying and for weighing.

3.1. Nest unit

The nest unit has two functions: to weigh the birds and to identify birds by reading the electronic tags of the birds. We will describe these two functions below.

A. Weighing

The "*load cell* "is a small metal box with a pin on which the nest tray is placed. Inside the metal box is an electronic bridge which consists of four size dependent resistors for measuring the weight (the resistors are put in a bridge to prevent effects of temperature changes and of bending when the force is not completely vertical).

The load cell registers the weight applied by the nest tray. The minimal weight differences that can be detected by the load cell is 1 gram. It corrects for deviations if the bird is not sitting in the middle of the nest tray. On top of the load cell is an nest tray placed on which the birds make their nests.

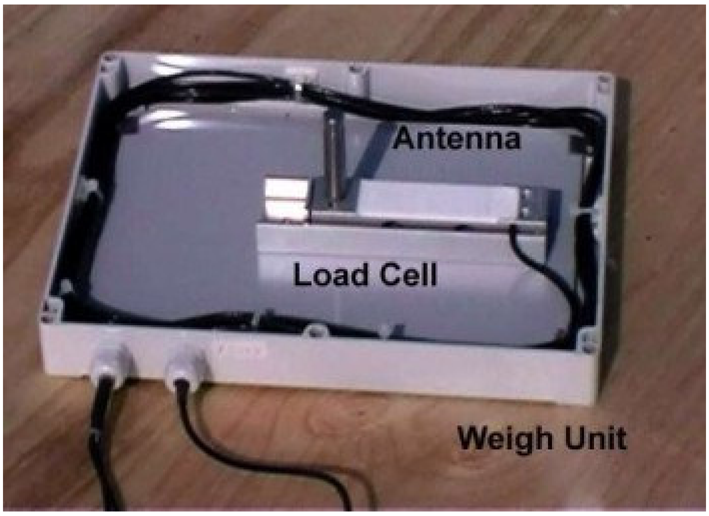


Fig 3. Inside view of an opened nest unit, which shows the antenna and the load cell

It should be noted that a load cell cannot distinguish what is actually on the nest tray, so it could be a bird, a chick, an egg, stones or snow, or a combination of all this. If the bird is marked with a transponder the nest can read the number (see B. Identifying), but the weight could be changed by stones that are removed by the bird or by snow.

In the 1998/99 season the load cells had a new built-in overload protection. In this way the load cell will not be damaged by weights higher than its maximum capacity. Overloading of the load cells could affect the proper functioning.

In the Ardery Island system the load cell weighs the same nest five times in a couple seconds. If the measurements are unstable, i.e. if there is much variation between the five consecutive weight measurements, this will result in high standard deviations of weigh data. The standard deviation of each weigh session is calculated by the logger computer.

B. Identifying

The artificial nest system uses the TIRIS system for identifying the birds. The TIRIS system is developed by Texas Instruments to identify objects from a distance. The birds in the study areas on Ardery Island have electronic tags in a 19mm long glass tube (see fig 4.), implanted under the skin of their legs. They are the "*transponders*".

Fig 4. Photo of 19mm TIRIS transponder. Photo: W. van der Veer.

Each transponder sends a unique signal, which is received by an *antenna* inside the nest-unit. These tags are called Passive Identification Tags (PIT) as they do not require a battery. Therefore, in principle they last for life of a bird.

The *antenna* is a coiled wire in the nest unit for reading the transponders. Reading a transponder is done in two steps:

- The electronic box sends a high current through the coiled wire, which results in a magnetic field. This field is picked up by an inductor in the transponder of the bird and it charges a capacitor in the transponder.
- After the short high current flow, the antenna functions as a normal antenna and receives the signal that the transponder sent, using the energy from the charged capacitor.

3.2. Nest tray

On top of the load cell is the *nest-tray.* This is where the birds make their nests. Nest-trays have raised sides to prevent the eggs falling off the artificial nest. Also in this way most stones will stay on the nest, as petrels like to build their own nest and to place stones around them. Drainage holes prevent the nest from flooding when the snow melts in the tray.

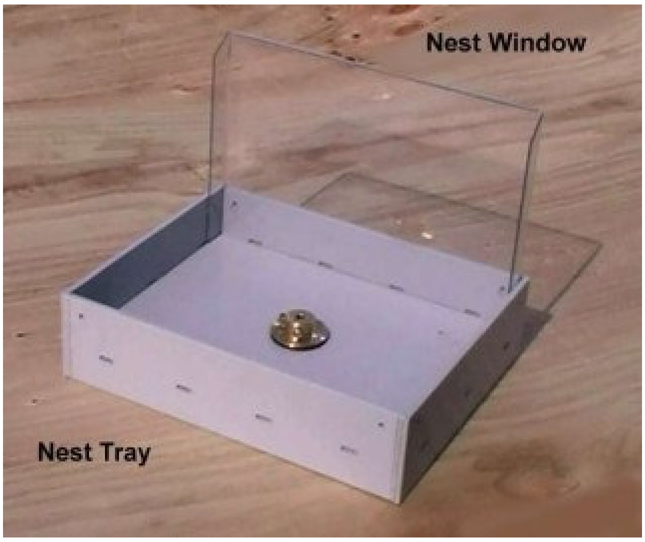


Fig. 5. Photo of nest tray. This nest tray shows an optional nest window which can be attached to the nest tray to avoid unreliable measurements when the bird is loaning against a rock wall.

The sides have the possibility to be extended with a screen, to avoid unreliable measurements of birds loaning against the rock. Unreliable measurements are expected when a bird touches a rock as a part of the gravity force of the bird will be lost in the rock if the bird is sitting against the rock.

3.3. Electronic box

Each nest unit has a separate aluminium box with the electronics inside for weighing and identifying the birds. The electronics are separated from the sensors in the nest unit to avoid disturbance to the birds. If the electronics fail, the electronic box can be disconnected for inspection or repair, while the actual nest unit, on which the bird breeds, stays in place.

The electronic box contains four print boards (see fig. 6) to control the transponder reading, the weighing and the power and data flow.

There is one main print board, which selects the function (transponder reading or weighing), and directs the power and the data flow to the print boards of the selected function for operating.

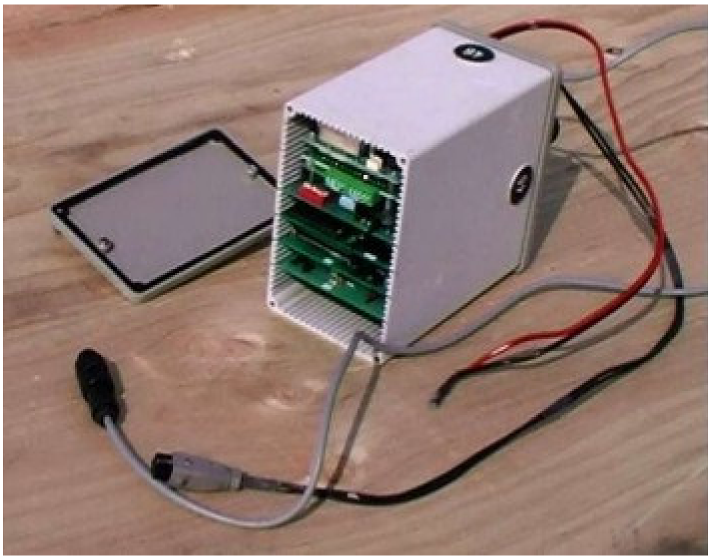


Fig. 6. Inside view of the electronic box which shows the four print boards, which can be easily replaced by non-technical people.

If one of these print boards fails, it can be easily removed and replaced with another print board by non-technical field workers.

The electronic box runs on 24V, which is, in the Ardery Island set up, generated in a separate set of solar panels near the study colonies. Inside the electronic box the incoming 24V is transformed by the main print board to 12V for the transponder reading and 5V for the other electronics.

Optionally, an emergency power supply (a continuously charged spare 12V battery) can be connected to the electronic box to power the unit for a while when the main power supply is low or disconnected.

The reason for having the normal power on 24V, but having a spare battery of 12V, is that the long distance from the energy system to the nest units causes power loss. The spare battery is located on the electronic box.

3.4. Interface box

The artificial nest system on Ardery Island uses an interface box to convert the RS485 data from the artificial nests to RS232 data, which the computer can read on its serial port. RS485 is used because of the distances in the field between the artificial nests and the computer. In the current set up the study areas are located up to 700m away from the logger computer in the field hut.

The difference between RS485 and RS232 is that RS485 uses current and RS232 uses low voltage.

3.5. Logger computer

A logger computer is used to control and manage the nest system, and to retrieve the data from the nests in the field. This computer runs an especially designed program for the Ardery Island artificial nest system (see The software).

The logger computer activates in the logger mode each nest sequentially, reads the transponder ID, measures the weight and deactivates the nest again, and goes to the next nest.

4. The software

The software runs under MS DOS and can be used on any IBM PC compatible with a 80286 processor or better. The reason why the program runs under MS DOS is that programming is less complex and the environment is more stable. The measurements are written down in a ASCII output file.

The program contains a text based user interface with nice ANSI colours. The program has two modes:

- The interactive manual mode for calibrating, testing and tuning the individual nests.
- The logger mode for continuous data collecting from all desired connected artificial nests.

Data that is obtained when the logger mode is active is:

- The transponder number
- The average weight of the measurements and the standard deviation
- The nest I/O number (not saved to output file)
- The battery status (not saved to output file)
- The date and the time of measuring

On the screen of the logger computer this information appears. In the logger mode it also shows the current weighing of TIRIS reading of each individual artificial nest. There are 7 information screens which shows the last information per 10 artificial nests.
There are also other information screens to see the number of errors or records, specified per each nest, since the last you started the system.

If the program saves every measurement you would get a real huge output file. Therefore on Ardery Island a reduction of the enormous output of data is obtained by options in the program to write only the changed values to the output file.
Changes of the measured values could be:

- Another or no transponder number
- A change in the weight.

However, after a number of cycles without any changes, the measurements are written to the output file. This is done to avoid that small changes are not detected for long periods. You can set the number of the cycles and the weight change sensitivity for each individual nest in a certain configuration file.

An example of a few lines of an output file is given below:

```
19981208000719   12         0  1994     3   1  08-Dec-98 00:07:19 T011  -1
19981208000758   21   2548471  1408     0   1  08-Dec-98 00:07:58 F055  541
19981208000859   36   2549015  1849     0   1  08-Dec-98 00:08:59 F040  9
19981208000957   51         0   247     0   1  08-Dec-98 00:09:57 T101  0
19981208001104   12   2543052  1996     5   1  08-Dec-98 00:11:04 T011  -1
19981208001210   28         0  2054     1   1  08-Dec-98 00:12:10 F046  563
19981208001249   37   2543011  1493     0   1  08-Dec-98 00:12:49 T037  -1
19981208001338   51   2647952   248     0   1  08-Dec-98 00:13:38 T101  0
19981208001536   24         0     7     6   1  08-Dec-98 00:15:36 F056  -16
19981208001624   36         0  1849     0   1  08-Dec-98 00:16:24 F040  9
19981208001827   12   2543052  1995     0   1  08-Dec-98 00:18:27 T011  -1
```

The respective columns represent from left to right:

- a *datetime code*, a combination of the date and time in seconds;
- the *artificial nest number*;
- the *TIRIS-number* of the bird (zero if not detected or not present);
- the average weight of the bird(s) on the artificial nest;
- *standard deviation of the recorded weight*, as each weight measurement is done five times within a couple of seconds. A SD of 0 means that all 5 measurements were similar. Higher SDs are expected when the birds are restless or when there is much wind.
- a *code for the power status*, to check if the nest got enough power for the measurements;
- *date*, to make it easier to read the output files;
- *time*, to make it easier to read the output files;
- *permanent nest number* in the colony (nests can be placed on different locations each year;
- and the *last zero-weight* (recorded without bird on the nest). To get the real weight the last zero-weight has to be subtracted from the recorded average weight value, thus the weight of the two birds on artificial nest 12 in the first line is 1993 - (-1) = 1994 grams. The weight of the bird of artificial nest 21 in the second line is 1408 - 541 = 867 grams.

On Ardery Island the calibration of the nests is done in the field, as normally recalibration is required after installation the nests. Sometimes recalibration of an artificial nest is needed during the season. Recalibration in the Ardery Island set up involves two persons. One person is sitting behind the logger computer and has radio contact with the researcher in the field. The person in the field hut starts calibration option in the interactive mode of the logger computer. He gives the person in the field commands over the radio when and which calibration weights should be placed on the nest tray.

To run the system for long period with a limited power supply an "energy saving mode" is built in the program. This means that the logger computer is not continuously retrieving data, but only once an hour or once a day.

5. Results

Data obtained by the artificial nest system could reveal much information on the breeding biology and foraging ecology of the studied birds. The combination of data on the identity and on the weight makes it possible to answer many questions. Some examples follows below:

- weight loss of the parents during incubation,
- patterns and duration of incubation shifts of each parent,
- meal sizes for the chick delivered by the parents,
- number of meals
- weight loss of the chick, etc..

The automatic recording continues even at night or at unfavourable weather conditions, which makes a much more accurate study of breeding biology of the petrels possible.
Combination of the data of different nests in the same colony makes it possible to detect special events, for example when predators are present in the colony. High standard deviations of the weight data could indicate windy conditions, but also nervousness amongst the birds.

Fig 7 (left). A giant petrel just entered the colony and all birds are flown off the nests. A sudden drop in weights in the output file will be visible on all nests in this colony. Note that in 1996/97 when this picture was made a different version of the nest trays on the artificial nests were used.

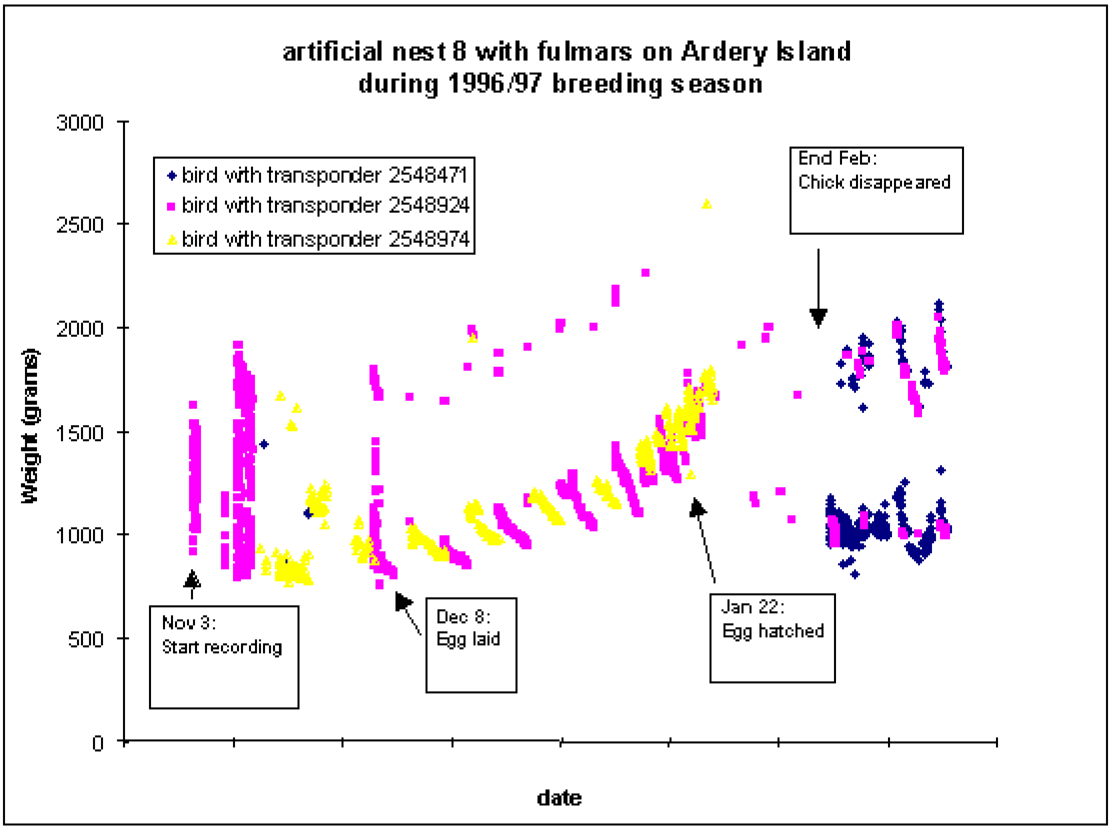
Fig 8 (right). An unlucky Antarctic petrel from the same colony (banded with white band A0010, visible on right leg) who couldn't escape quick enough is being eaten by a Southern giant petrel.

In the three examples below we show what data you can get and how to interpret them. At present there has not been much time yet to analyse and to process the data. Therefore in these examples confounding influences such as falling snow, or when birds are putting stones on a nest or are removing stones from a nest are still not removed.
We are still in the process of developing a computer program for an automatic analysis of the artificial nest data.

Example 1. Overview of a whole breeding season

In graph 1 an example is given of raw data generated by an artificial nest in the 1996/97 season. Two fulmars (TIRIS-numbers 2548974 and 2546924) were breeding on artificial nest 8. As explained below these data do not present a normal typical chick grow season.
In this example only data are shown when the TIRIS-transponder was read, and all data points are omitted where we recorded the weight but not the TIRIS number.

Till the beginning of February birds 2548974 and 2548924 were seen regularly on the nest, both were alternating the incubation shifts. The egg was laid at December 8th and the chick hatched at the January 22nd . After February 6th bird 2548974 disappeared and was not recorded on the nest anymore.
During our daily visits of the study colony we saw the chick badly injured at its head by the end of February. This coincided with a new number appearing on this artificial nest: 2548471. From the end of February the chick started wandering all over the colony and died eventually by starvation.



Graph 1. An example of data that can be obtained with artificial nest during a whole breeding season. Only data are used when a transponder was read. Two birds (with TIRIS numbers 2548924 and 2548974) were breeding on the nest and after February 6th bird 2548974 disappeared. By the end of February bird 2548471 was regular seen with 2548924. Each unit on the X-axis represent 20 days. For more explanation see the text.

By combining the data by visual observations and obtained by the artificial nest system we concluded that bird 2548924 had a new partner (2548471) in the second half of the season, when the original partner failed to back come the nest. Strikingly, early in the season this particular bird had been recorded a few times on this nest. Probably the new partner did not accept the chick and chased it away.

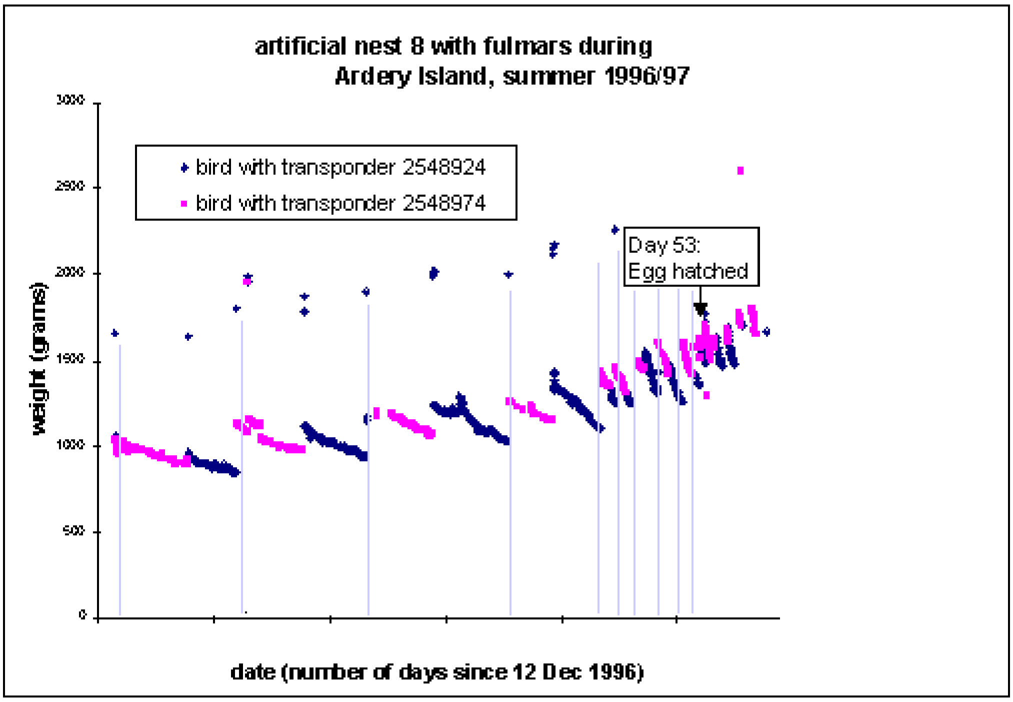
From the graph it can be concluded when a single bird is sitting on the nest or when they are sitting together. At times when two birds are sitting together on the nest an upper line of dots of around 2000g appears.
In the graph there not many dots on this line as we omitted all points without a TIRIS number. If two birds with a TIRIS-number are sitting together on an artificial nest often none of the numbers will be read.

In February only a few data-points are recorded as this is the time that parents leave their chick more and more alone to collect food at sea. The chick has no TIRIS number. We will look more into detail in the third example.

We just have finished a program to analyse the data where we have only data for weight but no data for the TIRIS-number. As TIRIS-detection was not 100%, we assumed that if there is no weight change in a short interval between two similar TIRIS-readings, the same bird is still sitting on the nest. In the program we can set the length of the interval. (We have not used the 'assumed' data points in the graph).

Example 2. Close up of the incubation period

The same data-set was used for Graph 2, but only data from Dec 12th 1996 till the end of January 1997 were selected. This period covers almost the whole incubation time. We also selected only data with a low standard deviation. As there are many data points with a high SD around egg-laying, these weights are not selected for the graph.



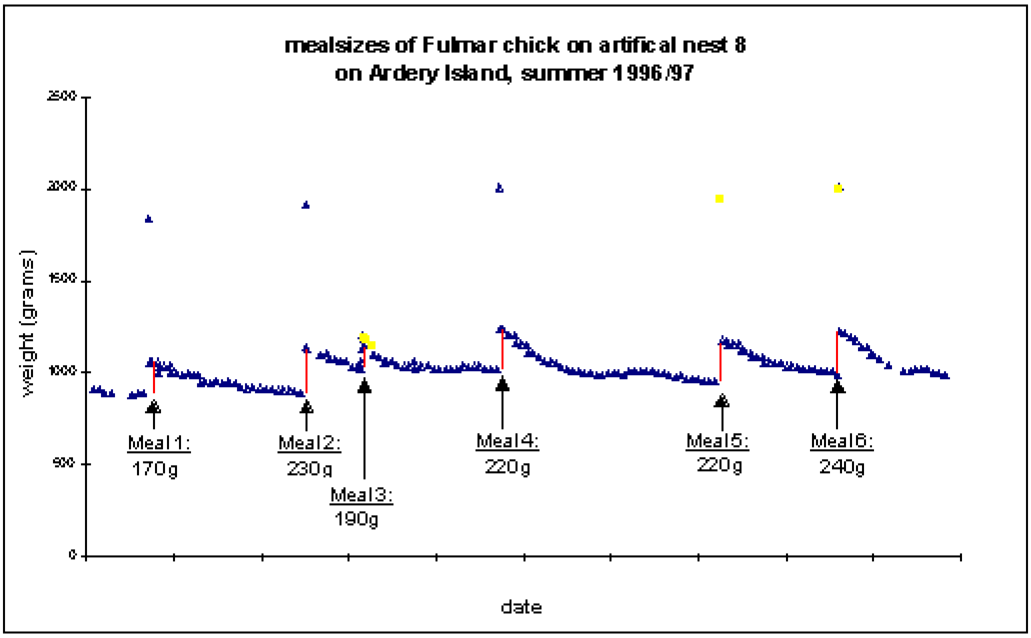
Graph 2. Example of a close up of the incubation period of Southern fulmars. The same data as in graph 1 were used, but only data with low standard deviations were selected. Each unit on the X-axis represent 10 days.

From the graph it can be concluded how long birds sit on their egg and how often they alternate. In the graph it can be seen that around 10 days before hatching the incubation shifts became much shorter. Before this moment the fulmars on this nest were sitting up to 4-5 days on their egg, and after that only half a day up to 1 day.

The graph also show how the body weights changes during incubation. Although the parents loose weight while incubating the egg, overall they gain body weight during incubation. Towards hatching they seem to loose body weight faster than in the beginning, but still they are becoming heavier and

Example 3. Deliveries of meals to a chick

In the next graph another sub-sample of data is used from the same nest (artificial nest 8) in the same season. Graph 3 shows all recorded raw data with a low standard deviation (SD less or equal to 1) from 13 February 1997 till 18 February 1997 of the same artificial nest (nest 8) during the same breeding season. The difference with the first example is that in this example **all** weight measurements are used, thus also when no TIRIS numbers was read. On Ardery Island petrel chicks are not injected with transponders, so the only time the artificial nest can read a TIRIS number is when the parents comes to deliver a meal. The graph shows how fast the chick gains and looses weight. The sudden weight changes in the graph are caused by the delivery of food by the parents. In this particular case there was only one parent delivering meals. Graph 3 is an atypical example as at this stage only one parent was feeding its chick. This atypical example explains why the chick was not much growing, the weight of the nest stayed roughly around the 1 kg.



Graph 3. Example of weigh data to estimate the meal sizes of chick at an artificial nest All recorded data are used, as the chick has no transponder injected. Units on the X-axis are in 12 hour-periods, from Feb 13 till Feb 18, 1997.

The average of the six meals delivered in 5 days is around 210 grams. The parent weighs about 780 grams, which means it delivers more than a quarter of its own weight to the chick.

Fig. 9 Meal delivery by an Antarctic petrel to its chick at an artificial nest. As chicks grow bigger there is no place left for the parents on the nest. This is a normal situation which also occurs on natural nests

Petrel parents normally do not hang around their chicks for long. After the meal-delivery they fly off soon, normally within half an hour. The few dots between 1800 and 2100 grams show when the parent and the chick are sitting there together. The reason that there are so few data points with a chick and a parent together is not only because of the short time they stay with the chicks. Also when petrel chicks are growing there is no space on the nest left for the parent (as can be seen on fig. 9).
The actual weight of the chick could only be determined if you know what the real weight of the nest itself is. Therefore regularly the "zero-weights" have to be established, the weight when the chick or bird is removed from the nest. In our examples have shown only raw data.

6. More information?

More information about the artificial nest system can be obtained from:

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