# Temperature Sensing

***Specialists in Animal Monitoring***

**Biotrack temperature-sensing tags are used mainly in studies of activity, behaviour, and mortality, rather than for absolute temperature measurement. The basic principle of temperature telemetry is that the pulse rate is changed by sensors, called thermistors.**

Tag life depends on pulse rate. To make the tag last as long as possible, tags should pulse slower during the activity the animal does most, often resting. Also, faster pulse rates are easier to track, which is more helpful when animals are active.

**Ambient temperature** can be sensed when the thermistor is on the outside of the tag; exposed to the air temperature. This type of temperature sensing has been used to detect when squirrels are in their drey, or when out foraging (Kenward, 1982). Usually, a warm thermistor (squirrel in drey) produces a slow pulse rate, and a cold thermistor (squirrel foraging) makes the pulse rate fast. Similar results can be obtained from most small to medium-size mammals that use nests or hibernacula in cooler climates.

Ambient temperature sensing can also be used with birds to detect flight (Cresswell, 1992). A thermistor on a lead is placed under the wing, where it is warm when the wing is folded at rest. When the bird flies the thermistor quickly cools with the underwing airflow, resulting in a faster pulse rate.

Cresswell, B. (1992). Use of thermistors in radio tags. In "Wildlife Telemetry - Remote Monitoring and Tracking of Animals" (I.G. Priede, and S.M. Swift, eds), 98-99. Ellis Horwood, Chichester, UK.

Kenward, R.E. (1982) Techniques for monitoring the behaviour of grey squirrels by radio. In "Telemetric Studies of Vertebrates" (C.L. Cheeseman and R.B. Mitson, eds), 175-196. Academic Press, UK.

**Body temperature** can be monitored by placing the thermistor under the tag, against the animal's skin or fur. For example, when a bat is hibernating, its body temperature drops low and when active the body temperature increases. Setting the pulse rate low when the animal is hibernating extends the battery life, but still allows any temporary activity/warming to be recorded.

Body temperature sensing can also be used to detect mortality, because dead animals are colder. A faster pulse rate indicates mortality; when long battery life is no longer needed. Quick detection of a mortality event can greatly enhance investigations into causes of death. Thermistors do not re-set like "movement-and-timer" based sensors, which can switch back to the "alive" signal, e.g. if scavengers move the tag. However, thermistors can be heated up to body temperature by the sun in some climates, in which case checks should be conducted at cooler times of day.

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**Temperature measurements** can have a RESOLUTION better than 0.1ºC, but only if high precision pulse interval measurements can be made during calibration and use. However, ACCURACY will not necessarily be as good. Due to circuit variables such as battery voltage, circuit temperature (as distinct from sensor temperature) etc, the typical accuracy of a temperature-sensing transmitter will be around ± 2ºC over the life of the battery. Temperature measurements made using radio-tags should be treated with caution. If possible, tags should be recalibrated after use, to ensure that the calibration remains valid and within expected error margins.

Further error can be introduced in tags designed for measuring body temperature. Typically a sensor on an external tag touches the animal's skin/fur, which is unlikely to be the same as its core body temperature. Furthermore, fluctuations in the amount of contact between the sensor and the skin can give erroneous changes in measured temperature. Likewise the tag itself can gain and lose heat at a different rate to the animal’s body.

**Measuring pulse intervals is the best method** for temperature-sensing applications where there is continuous variation (not distinct pulse rates). Often pulses are either fast or slow, and it is easy to tell one from the other without the need to measure them, such as in the squirrel example overleaf. When measuring temperature, it is possible to make accurate measurements with a simple stopwatch. Pulse detection equipment is only necessary for automated data collection (e.g. by a data logger).

**To measure pulse interval:** use a stopwatch to time a number of pulses, then divide the number of seconds by the number of pulses. Pulse interval measurements made with a handheld stopwatch are surprisingly repeatable, usually to within about 5/100s of a second. This source of error (mainly variation in the exact time when the button is pressed) would be significant if only one pulse interval was measured, but can be 'diluted' by timing a series of pulses. For example, an average error of 50 ms over one pulse interval of 1 s is 5%, but the same average error over 10 pulse intervals (10 s) would represent an error of only 0.5%. Of course this assumes that pulse interval does not change during the timed pulses, but on the whole this is a safe assumption to make, and one that is easily tested.

**Counting pulses per minute is a less accurate measure.** Just counting the number of pulses that occur within a fixed period is a very crude measure of pulse rate. Although it is easier to measure than pulse interval measurements, it results in an error of up to ± 1 pulse interval. Using the example above, counting the number of pulses in ten seconds could give an error of up to ±1 second (10%) whereas the error in timing pulses was only 50 ms (0.5%), a 20-fold increase.


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