Science Coursework: Huddling

Aim and Introduction

My aim is to find out the heat conservation advantages are for penguins are when huddling. I will be huddling boiling tubes (to represent the penguins) containing hot water (to represent the penguins' blood) and measuring the temperature over a period of time. I also had a control boiling tube on its own to see how the temperature is affected by not huddling.

To keep themselves warm penguins use blubber as well as stiff tightly packed feathers (up to 70 per sq in). These feathers also overlap and provide waterproofing. They coat these feathers with oil from a special gland to make them impermeable to water. New ones grow underneath, but penguins grow new feathers under the old ones and then the old ones are shed all at once. Because Penguins are flightless this complete malting is no hazard to them

There are 18 different types of Penguins but they all have certain things in common. All penguins have the well-known tux coloration. Some are white and black and some are white and blue simultaneously. Colour in penguins is rare, being limited to red or yellow irises of the eye in some species, red beaks or feet in a few species, yellow brow tufts in the three species of *Eudyptes* and orange and yellow on the head, neck, and breast in the two species of *Aptenodytes*.

Penguins range from about 35 centimetres (14 inches) in height and approximately one kilogram (about two pounds) in weight, in the little blue, or fairy, penguin (Eudyptula minor), to 115 centimetres (45 inches) and 25 to 40 kilograms (55 to 90 pounds) in the emperor penguin (*Aptenodytes forsteri*)

The total populations of some species, such as the emperor penguin, are estimated in hundreds of thousands, but those of most species of smaller penguins certainly run to several million. The largest breeding colonies are on the islands between 50° south latitude and Antarctica. These immense colonies, some of which contain hundreds of thousands of individuals, represent a large potential food resource, but the economic importance of penguins is negligible.

Nineteenth-century whalers and seal hunters visited some colonies for meat and eggs, and a penguin oil industry once took large numbers of birds; by the early 20th century, however, this exploitation was no longer profitable, and most colonies were left alone or actively protected. Some species are now increasing in numbers, apparently as a result of the drastic reduction of Antarctic whales, which compete with penguins for the krill on which both feed.

Variables

The variables in this experiment are water temperature, boiling tube size, amount of boiling tubes in the huddle, amount of water in the boiling tubes, time between tests, room temperature and position of boiling tubes. There are a lot more variables but these are the ones I believe to be the main ones.

My chosen variable is huddling.

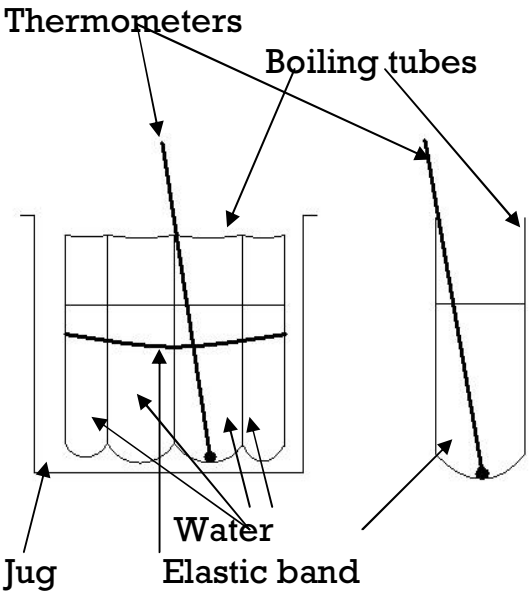
Prediction

My prediction is that the centre penguin will stay warmer then the outer penguins as more heat will transfer (through convection and conduction) towards the middle penguin from the outer penguins then the middle penguin will transfer towards the outer penguins from the middle penguin, as there is a smaller amount of heat with more penguins to absorb the heat.

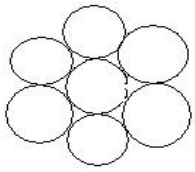
Apparatus

Eight Boiling tubes	Kettle
-10 degrees centigrade – 110 degrees centigrade thermometers	
Stopwatch	Steadtler lumimark pen
Elastic band (rubber)	Beaker (500 ml)
Test tube rack	Measuring tube (25ml)
Plastic jug	

Diagram



Arrangement of boiling tubes



Method

- Measure out 20ml of cold water in a 25ml measuring tube and pour the water into a boiling tube. Mark off the water level with a Steadtler luminary pen. Empty the boiling tube. Repeat this for all eight boiling tubes.
- Wrap an elastic band around seven boiling tubes as arranged above. Place the boiling tubes in a jug for added stability and place the eighth boiling tube in a boiling tube rack. This is the control boiling tube.
- Fill all boiling tubes with water at 69 degrees centigrade
- Place a thermometer in the centre boiling tube, a random outer tube and the control tube.
- Start the stopwatch. Every 2 minutes take the temperature and note it down. Stop at 20 minutes.

Pilot test

Results

	Centre boiling tube (degrees centigrade)	Outer boiling tube (degrees centigrade)	Control tube (degrees centigrade)
Start temperature	69.0	69.0	69.0
2	68.5	66.0	54.0
4	68.0	64.0	52.0
6	66.0	56.0	49.0
8	63.0	55.0	48.0
10	60.0	54.0	45.0
12	59.0	53.0	41.0
14	56.0	52.0	40.0
16	54.0	50.0	38.0
18	53.0	49.0	37.0
20	51.0	47.0	36.0

Graph

See graph titled: A graph to show the results of the huddling experiment (pilot)

Conclusion

From the results you can see that the centre boiling tube is warmer all the way through the experiment then the outer boiling tube and control boiling tube. The middle boiling tube drops at a lot slower rate then the control boiling tube and the temperature dropped a little more in the centre boiling tube then the outer boiling tube towards the end of the experiment, however at the beginning of the experiment the temperature dropped a lot faster in the centre boiling tube.

As a result of this pilot test I am going to improve on certain aspects of the experiment. These aspects are:

1. My accuracy in taking the temperature.
2. My control of the start temperature. The start temperature seemed to drop very quickly in the first half minute.
3. The test conditions. I will try to make the surroundings of the experiment less affecting towards the experiment itself.

Main test

Method

The same as the method for the pilot.

Results

	Centre boiling tube (degrees centigrade)	Outer boiling tube (degrees centigrade)	Control tube (degrees centigrade)
Start temperature	69.0	69.0	69.0
2	58.5	58.5	52.5
4	57.0	56.8	44.75
6	55.0	54.0	41.5
8	53.5	51.5	39.0
10	52.5	50.5	37.0
12	51.75	49.0	35.0
14	50.65	48.5	33.55
16	49	46.5	32.5
18	47.95	45.5	30.5
20	46.75	44	29.85

Graph

See graph titled: A graph to show the results of the huddling experiment.

Conclusion

From the results you can see that the centre boiling tube is warmer all the way through the experiment than the outer boiling tube and control boiling tube. This is because a large portion of the heat from the outer penguins transferred (through convection and conduction) to the boiling tubes surrounding it. As each outer boiling tube only had 3 other boiling tubes next to it, these got a smaller percentage of the total transferred heat than the middle boiling tube, as this has 5 other boiling tubes adjacent to it. This means that the middle boiling tube receives more heat through convection then the others but is more likely to lose heat through conduction then the other boiling tubes as it is touching more boiling tubes. Because the surface area actually touching the other boiling tubes is very small not much heat will pass through this method, meaning that the heat loss through

conduction is very little and probably doesn't affect the results very much.

The middle boiling tube drops at a lot slower rate then the control boiling tube and the temperature dropped a little more in the centre boiling tube then the outer boiling tube towards the end of the experiment, however at the beginning of the experiment the temperature dropped a lot faster in the centre boiling tube. This is maybe because of the temperature of the boiling tubes, as, if they were cold, a lot of the heat from the water would be transferred to the boiling tube so it is the same temperature as the water. The heat is transferred because the vibrations from the heated atoms in the water cause the atoms in the glass to vibrate in a similar way, increasing the temperature of the glass, but lessening the violence of the atoms' vibrations in the water thus causing the temperature of the water to lower.

My prediction is supported by this conclusion, as I predicted that the centre penguin will stay warmer than the outer penguins as more heat will transfer (through convection and conduction) towards the middle penguin from the outer penguins than the middle penguin will transfer towards the outer penguins, as there is a smaller amount of heat with more penguins to absorb the heat. This is what happened in my test as is proved by the results.

The control boiling tube shows that by not huddling, a lot of heat is lost. As this experiment was only for a short period of time this is not a certain fact, but the control boiling tube probably would have lost all its heat in approximately 60 minutes (it was losing close to 0.5 of a degree centigrade every minute, and at 20 minutes the temperature was 30 degrees centigrade) this is not an accurate guess at how long a real penguin would have lost as penguins have insulation and produce their own heat as they are warm-blooded. This loss of heat shows that by huddling a lot of heat is conserved through conduction and convection between each penguin so there is a large advantage to huddling.

Evaluation

I think that my results are reliable as I tried to control everything about this experiment as much as possible so there was little margin for error.

The only odd results I think I have is the quite fast drop in temperature in the first six minutes but I blame that on the boiling tube temperature as the results for all the boiling tubes seem to do the same meaning that it took the same amount of time for the boiling tube temperature and the water temperature to equalise.

The method I used, in my opinion, worked very well. Maybe if I was experimenting with the effects of huddling at a higher level I would design the experiment to delve deeper into the effects of atmosphere and surrounding temperature, amount of penguins in the huddle, size of the penguin etc. ~~A~~another way to make the results more accurate would be to use a more accurate thermometer such as a digital thermometer. I could also make sure that the thermometer could move less, so it only takes a reading from one place in the boiling tube and not scattered, random parts of the water. However at this level of research into huddling I think the experiment worked perfectly.