HatchTech
INCUBATION TECHNOLOGY

Technical Information

High Altitude Incubation

Dr. Inge van Roovert-Reijrink M.Sc.

Incubation at high altitude is more difficult than incubation at sea level. The reason why incubation at high altitude is more difficult than incubation at sea level will be discussed in this article.

To optimize hatchability and chick quality, two incubation factors are highly important: embryo temperature and oxygen availability. These factors are influenced by high altitude incubation. Embryo temperature is the result of the embryonic heat production and heat transfer capacity of the air surrounding the embryo. When altitude increases, oxygen availability and heat transfer capacity of the air decreases. We will first explain the effect of high altitude incubation on oxygen availability and afterwards the effect on heat transfer capacity of the air.

When altitude increases, the partial pressure of air decreases. As a result the percentage of oxygen in the air remains the same, but the number of oxygen molecules per square meter is lower than at sea level. For example at 1,000 meter altitude, the percentage of oxygen remains around 21%, however the number of oxygen molecules is comparable to 18% of oxygen at sea level.
During the first 9 days of incubation, the oxygen consumption of an embryo is relatively low. The embryo will therefore not experience any difference in oxygen availability between incubation at sea level or incubation at high altitude. However, from day 9 of incubation onward the growth rate of the embryo increases and consequently oxygen consumption increases. At high altitude, the oxygen availability is, therefore, restricted earlier than at sea level, and this increases the percentage of embryonic mortality and retards embryonic development.
The problem of the lower oxygen availability can be solved by oxygen injection into the incubator. However, this is expensive and will

not completely solve the problem because high altitude also affects the heat transfer capacity of the air.

Hatchability and chick quality are maximized when the embryo temperature is maintained at 37.8°C throughout incubation. Since the heat transfer capacity of the air affects embryo temperatures, changes in the heat transfer capacity of the air that occur during high altitude incubation will have a major impact on embryonic development and hatchability.

Comparable to the oxygen molecules, the number of water molecules in the air decreases as altitude increases. This reduces the heat transfer capacity of air. Meijerhof (2001) showed that the heat transfer capacity of air decreases when altitude increases (Table 1). A relative humidity of 55% at sea level is comparable to a relative humidity of 36% at an altitude of 2,000 meter. To reach at a high altitude a similar heat transfer capacity of the air as with a relative humidity of 55% at sea level, the humidification system in the incubator has to spray more than at sea level. The cooling effect of the extra water that comes from the humidification system has a negative effect on embryo temperature because it cools the embryos that are situated nearby the humidification system. These embryos are retarded in growth and development. The end result is that the hatch window enlarges, hatchability declines, and hatched chicks are smaller.

Altitude	Heat Capacity kcal/kg air 37.5°C, 55% relative humidity	% Heat Capacity Compared to Sea Level	Theoretical % relative humidity at Sea Level, 37.5°C
Sea Level	23.0	100	55.0
600 meter	21.1	92	47.0
1000 meter	20.4	89	43.0
1500 meter	19.1	83	40.0
2000 meter	18.0	78	36.0

Table 1: *The percentage of heat capacity of the air compared to sea level and as a comparison the theoretical equivalent percentage of relative humidity at sea level (Meijerhof, 2001)*

Incubation at high altitude is difficult because the relative humidity that is important for heat transfer during incubation is not as affective as at sea level. If you want to incubate at high altitude you have to be sure that the incubator is designed in such a way that the embryo temperature can be maintained at 37.8°C although the air contains less water molecules. Factors that help to maintain the embryo temperature at 37.8°C are a uniform laminar airflow, high air velocity, and enough cooling capacity to increase the difference between embryo and air temperature. These factos are necessary to prevent embryo temperatures below 37.8°C during the first 9 days of incubation when heat production is low, but also to prevent embryo temperatures higher than 37.8°C when the heat production increases exponentially after day 9 of incubation.

The goal of incubation is to maximize hatchability and to hatch the best quality chicks. However, the physics of high altitude show us that this goal can only be achieved at sea level or at a maximum altitude of 500 to 600 meters. At altitudes higher than this, embryos will be too cold during the first 9 days of incubation and embryos will get overheated after day 9 of incubation when incubation factors such as a uniform laminar airflow, a high air velocity, and enough cooling capacity are not part of the incubator design. Due to overheating after day 9 of incubation, the metabolism of the embryo increases and consequently the oxygen requirement increases as well. Due to the lower oxygen availability at high altitude the negative effects of too high embryo temperatures on hatchability and chick quality, and chick performance in the field are larger at high altitude than at sea level.

The decrease in partial pressure of air when altitude increases makes optimal incubation difficult and hatchability and chick qualtity results highly depend on incubator design.

References

Meijerhof, R. 2001. Get me down. Hybro BV Boxmeer Publication.

19_314_HAT041