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Comparison of Infrared and electronic digital thermometry in growing broilers

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Additional keywords

Heat Stress.
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SUMMARY

Body temperature (BT) data obtained from 150 unsexed broiler chickens aged 28d were used to compare accuracy of different thermometers. Electronic digital (ED) and infrared (IR) thermometers were concurrently used to measure BT. ED thermometry was taken via the rectum (TEMPd) while the IR thermometer was used on the opening of the rectum (TEMPiR), forehead (TEMPiH) and under the wings (TEMPiW). The data were subjected to ANOVA and Pearson correlation analysis. Scatter diagrams were plotted to generate R2 for the relationships between thermometer readings. Thermometer type had significant (P<0.001) effect on BT in broiler chickens. TEMPd was similar (P>0.001) to TEMPiW, but the duo were significantly higher than TEMPiR and TEMPiH. TEMPiH was not significantly different from that of the opening of rectum. Positive (P<0.001) correlation exists between TEMPd and TEMPiW (r=0.327) while the correlation between TEMPd and TEMPiH was negative (r=-0.250). TEMPiR had no significant (P>0.05) correlation with TEMPd (r=0.061). Linear regression of TEMPd with TEMPiR; TEMPd with TEMPiH; and TEMPd with TEMPiW yielded R2 values of 0.003, 0.062 and 0.106 respectively. Deviations from TEMPd obtained were 3.63, 3.79 and -0.12oC for TEMPiR, TEMPiH and TEMPiW respectively. IR thermometer recorded lower readings on the forehead and near rectum than ED thermometers in broiler chickens. Thermometry with IR under wings gave a closer reading with ED thermometer. Accuracy of IR thermometer in broilers depends on the point on the body surface from which the reading is taken. Readings with IR under the wings mimic the core body temperature.

Comparación de la termometría digital infrarroja y electrónica en pollos de engorde

Palabras clave adicionales

Estrés termico.
Salud.
Bienestar.
Diagnostic.
Aves de corral.
Termorregulación.

RESUMEN

Se utilizaron datos de la temperatura corporal (BT) obtenidos de 150 pollos de engorde no envejecidos de 28 d de edad para comparar la exactitud de los diferentes termómetros. Se utilizaron simultáneamente termómetros digitales electrónicos (ED) e infrarrojos (IR) para medir BT. La termometría de ED se realizó a través del recto (TEMPd) mientras que el termómetro IR se usó en la apertura del recto (TEMPiR), la frente (TEMPiH) y bajo las alas (TEMPiW). Los datos se sometieron a análisis de correlación de ANOVA y Pearson. Diagramas de dispersión se representaron para generar R2 para las relaciones entre las lecturas del termómetro. El tipo de termómetro tuvo un efecto significativo (P <0,001) sobre la BT en pollos de engorde. TEMPd fue similar (P> 0,001) a TEMPiW, pero el dúo fue significativamente mayor que TEMPiR y TEMPiH. TEMPiH no fue significativamente diferente de la de la apertura del recto. Existe correlación positiva entre TEMPd y TEMPiW (r = 0.327) mientras que la correlación entre TEMPd y TEMPiH es negativa (r = -0.250). TEMPiR no tuvo correlación significativa (P> 0,05) con TEMPd (r = 0,061). Regresión lineal de TEMPd con TEMPiR, TEMPiH y TEMPiW rindió R2 valores de 0,003, 0,062 y 0,106, respectivamente. Las desviaciones de TEMPd obtenidas fueron de 3,63, 3,79 y -0,12oC para TEMPiR, TEMPiH y TEMPiW, respectivamente. TEMPiR y TEMPiH en pollos de engorde no produjeron lecturas similares en comparación con los termómetros ED. La termometría con IR debajo de las alas dio una lectura más cercana con el termómetro ED. La precisión del termómetro IR en los pollos de engorde depende del punto en la superficie del cuerpo del que se toma la lectura. Las lecturas con IR debajo de las alas imitan la temperatura corporal central.

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INTRODUCTION

Infra-red (IR) non-contact thermometer had been in use in human long time ago in different parts of the world. However, it became commonly used in Nigeria during the scourge of *Ebola* in the west coast of Africa (Musa et al. 2015, pp. 331-6; Ohimain 2015, pp 11-20; Patrick & Major 2015, pp. 63-7; Haastrup 2016, pp. 71-80). The use in monitoring body temperature has been extended to livestock sector of economy. Body temperature of farm animal is monitored easily with the device both on-farm and at livestock research centres, replacing the traditional clinical (mercury-in-glass, MG and electronic digital, ED) thermometers. Necessity to ascertain health status and ensure that the animals are stress-free makes monitoring of body temperature imperative (Stephens Devalle 2005, pp. 35-8; Brunnel 2012, pp. 479-84). Although core body temperature is

the parameter that best reflects a bird's thermal status, practical and physiological obstacles make it irrelevant as a source of information on the thermal status of commercial flocks (Giloh, Shinder & Yahav 2012, pp. 175-88). This makes it important to measure skin surface temperature.

Broiler chickens are more prone to heat stress during growing-finishing phase than starting phase. Broiler productivity suffers under the influence of heat stress in the tropics and during summer in the temperate regions (Lin et al. 2006, pp. 71-86; Sunil Kumar, Kumar & Kataria 2011, pp. 45-54) when environmental temperature is often above thermo-neutral zone of most poultry species. It results in hyperthermia (Altan et al. 2000, pp. 489-93; Garriga et al. 2006, pp. 195-201) which leads to a cascade of events that affect the well-being of the birds. The foregoing justifies the need for accurate monitoring of the welfare of broiler chickens. Body temperature is one of the indicators of heat stress in farm animals (Abioja et al. 2012, pp. 1-6). Body temperature measurements via the rectum of Red Sokoto (RS) goats were reported recently to be similar in mercury-in-glass and electronic digital thermometers (Abioja et al. 2012, pp. 1-6). Information on comparison of different thermometers in chickens is not readily available. However, the use of individual type of thermometer had been reported in literatures (Abioja et al. 2013, pp24-36; Adekunle et al. 2017, pp 15-20). It becomes imperative to ascertain the accuracy of newly introduced IR thermometer in measuring body temperature in broiler chickens. Therefore, this study aimed at comparing the data of thermometry taken with ED thermometers with the non-contact IR thermometer on the forehead, at the opening of the rectum and under the wings of broiler chickens.

MATERIALS AND METHODS

Location

The research was carried out at the Poultry Unit of the University Teaching and Research Farm, Federal University of Agriculture, Alabata Road, Abeokuta, Nigeria (latitude 7° 13′ 49.46″N; longitude 3° 26′ 11.98″E (Google Earth, 2016) and altitude 76 m above sea level).

Meteorological observations

Ambient temperature and relative humidity in the pens were monitored during data collection with digital thermal hygrometer.

Experimental animals and management

One hundred and fifty unsexed *Arbor acres* broiler chickens aged 28d kept in open-sided, wood-shaving floor pens were used for this experiment. The animals were fed *ad libitum* with commercial broiler finisher mash. Fresh water was made available *ad libitum* daily. Vaccination programme and recommended medications were adequately adhered to.

Data collection

Body temperature measurement on all the chickens was carried out using two different (ED and IR) thermometers. ED thermometer was used to measure body temperature via rectum of the animals (TEMPd) while body temperature measurement with infra-red non-contact thermometer was done on the forehead (TEMPiH), at the opening of the rectum (TEMPiR) and under wings of broiler chickens. The four readings were taken at the same time on individual birds. The measurement was done for 5 days when the birds were 28-32d.

Electronic digital thermometer

Electronic digital (ED) thermometer (*Jorita*®, China with 0.1°C accuracy) was inserted into the rectum of chickens and held in contact with the epithelial lining until it beeped as earlier described by Abioja et al. (2012, pp. 1-6).

Infra-red non-contact thermometer

Body temperatures of chickens were taken by beaming the laser from the IR thermometer (model DT-8806C, China with 0.3°C accuracy) on the forehead, at the opening of the rectum and under wings of the birds (Abioja et al. 2016, pp. 299-306). It was ensured that the distance between the animal and the thermometer did not exceed the value recommended by the manufacturer.

Data analyses

Data collected were subjected to analysis of variance using SYSTAT analytical statistical package version 5.0 (SYSTAT, 1992). Means that are statistically different were separated using Duncan Multiple Range Test. The data on TEMPd, TEMPiH, TEMPiR and TEMPiW were further subjected to Pearson correlation analysis. Taken TEMPd as the dependent variable, scatter diagrams were plotted to generate R squared for the relationships with the readings of the IR thermometers on different spots on the body surface.

RESULTS

Effect of thermometer type on body temperature of broiler chickens is presented in **Figure 1**. Thermometer type had significant ($P<0.001$) effect on BT in the birds. TEMPd (41.14°C) was similar to TEMPiW (41.25°C), but the two were significantly higher than TEMPiR (37.51°C) and TEMPiH (37.35°C). There was no significant difference between TEMPiH and TEMPiR. **Table I** shows the correlation matrix among the values obtained with different thermometers in broiler chickens. There was a positive significant ($P<0.001$) correlation between TEMPd and TEMPiW ($r=0.327$). Correlation of TEMPd with TEMPiH yielded coefficient of -0.250. Scatter diagrams showing the relationships between readings of TEMPd against TEMPiR, TEMPiH and TEMPiW are presented in **Figures 2-4** respectively. TEMPd had regression coefficients R^2 of 0.003, 0.062 and 0.106 with TEMPiR, TEMPiH and TEMPiW respectively. **Table II** shows the deviations of the readings of other thermometer types from the electronic digital thermometer. Deviations from TEMPd obtained were 3.63, 3.79 and -0.12°C for TEMPiR, TEMPiH and TEMPiW respectively.

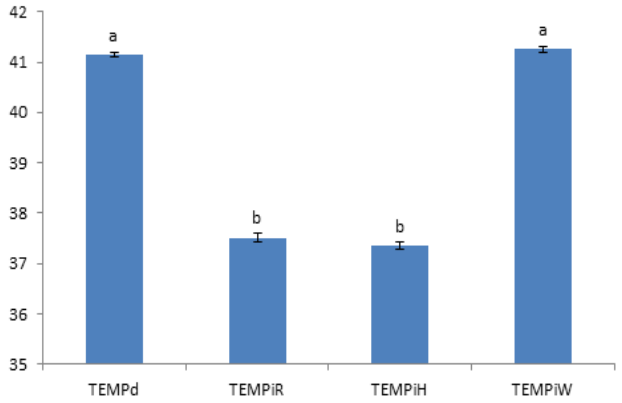

Figure 1. Body temperature (°C) of broiler chickens as affected by thermometer type (La temperatura corporal (°C) de pollos de engorde se ve afectada por el tipo de termómetro) [a,b]Means with different letters in different section of the chart differ significantly (P<0.001).

DISCUSSION

Usually, the core body temperature is higher than skin temperature in animals (Abioja et al. 2016, pp. 299-306), as most of the metabolic heat production takes place in the core. The hottest part is found around the liver in vertebrates. There exists a heat gradient from the core to the shell outside. Ng, Chan and Lau (2005, pp. 227-9) had stated that to obtain estimated core temperature approximately 2 degrees must be added to the measured skin temperature. In the present study, the addition to the core body temperature should be up to 3.6 and 3.8°C for infrared thermometry on the opening of rectum and on the forehead in broiler chickens respectively. Skin temperature measurement taken on the forehead is not a good representative of core body temperature (Dräger, 2015, pp. 1-58) because of its sensitivity to a number of external and internal factors (Casa et al. 2007, pp. 333-42). An animal situated directly in front of air conditioner or fan is likely to exhibit lower skin temperature. The aim of measuring temperature on the forehead is to obtain the brain

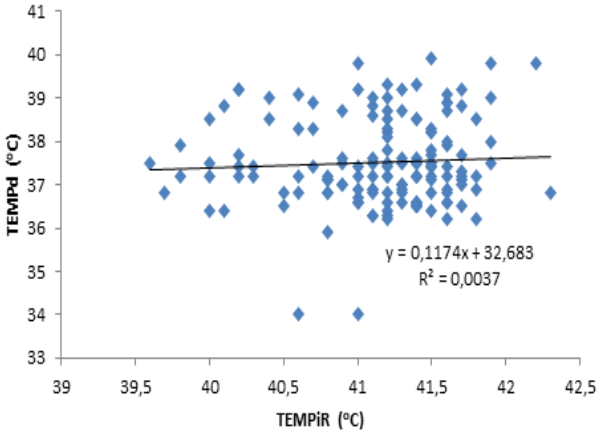

Figure 2. Scatter diagram of temperature readings of ED against IR at the opening of the rectum (Diagrama de dispersión de las lecturas de temperatura de la ED contra IR en la apertura rectal).

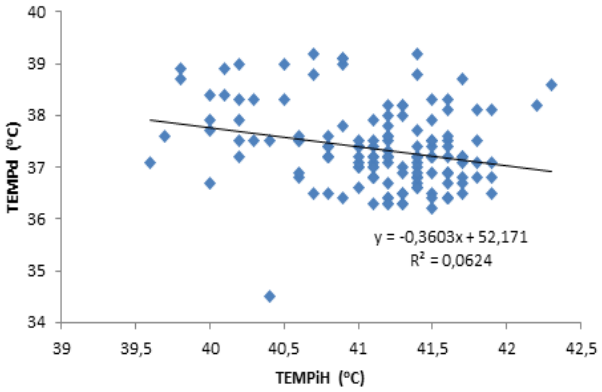

Figure 3. Scatter diagram of temperature readings of ED against IR at the forehead (Diagrama de dispersión de lecturas de temperatura de ED contra IR en la frente)

temperature. However, the skull can stand as barrier to penetration of laser beam of the infrared into the brain and thereby limit the accuracy of the reading. Abioja et al. (2016, pp. 299-306) reported extremely low value for infrared thermometry on forehead of Red Sokoto goats. In this study, the values obtained with infra-red non-contact thermometer under the wings of growing broiler chickens were similar to that of the rectal temperature obtained with electronic digital thermometer. Earlier in human, body temperature at the armpit has been found to be close to core temperature by different authors (Singh et al. 2000, pp. 898; Gasim et al. 2013, pp. 1-5). Measurement at the opening of the rectum and on the forehead with infrared thermometer gave relatively lower values compared to rectal temperature. In fact, the mean values obtained with infrared thermometer on these two spots (37.51 and 37.35°C) were below normal body temperature values (41.5-42.5°C) in literatures for broiler chickens. Monitoring body temperature with infrared thermometer actually measures skin temperature (Dräger, 2015, pp. 1-58), as there are often barriers that shield off the core part of the body from the body surface. However a report on infrared thermal imaging in broiler chickens exposed to heat stress revealed that skin surface temperature of

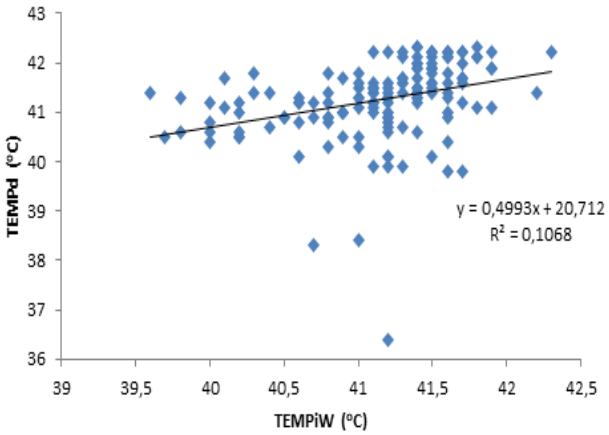

Figure 4. Scatter diagram of temperature readings of ED against IR under the wing (Diagrama de dispersión de lecturas de temperatura de ED contra IR bajo el ala).

Table I. Correlation matrix of the body temperature of broiler chickens measured with electronic digital (ED) and infrared (rectum opening, forehead and under wing) thermometers (Matriz de correlación de la temperatura corporal de pollos de engorde, medido con termómetros electrónicos digitales (ED) e infrarrojos (abertura del recto, frente y bajo ala).

	TEMPd	TEMPiR	TEMPiH	TEMPiW
TEMPd	1.000			
TEMPiR	0.061	1.000		
TEMPiH	-0.250**	-0.052	1.000	
TEMPiW	0.327***	-0.279***	-0.009	1.000

Table II. Deviations from readings of thermometer types from electronic digital thermometer (Desviaciones de las lecturas de los tipos de termómetro del termómetro digital electrónico).

Temperature readings	Bias (°C)	Standard deviation (°C)	Maximum (°C)	Minimum (°C)
ED-IR rectum	3.63	1.11	7.00	1.00
ED-IR forehead	3.79	1.03	5.90	0.90
ED- IR wing	-0.12	0.80	4.80	-1.80
IR wing- IR rectum	3.74	1.46	7.80	-1.00
IR wing - IR forehead	3.90	1.11	6.90	-0.80

broiler chickens of different ages is strongly correlated to body core temperature and that it is indicative of their thermoregulatory status (Giloh, Shinder & Yahav 2012, pp. 175-188). The use of infrared thermometer though easier and faster than the traditional mercury-in-glass and electronic digital thermometers (Rextroat, Benish & Fraden 1999, pp. 1-4), will however measure skin temperature better instead of core body temperature measured by the other two. Body temperature measurement depends on the type of thermometer used and portion of the body at which the temperature is taken (Rubia-Rubia et al. 2011, pp. 872-880). Moreover, lower temperature with IR thermometer on the forehead might have resulted from barrier of the skull. The skull is a thick bone case housing the brain, especially the frontal lobe. In contrast, Rextroat, Benish and Fraden (1999, pp.1-4) stated that closer relationship was obtained from infrared Vet-Temp™ VT100 instant tympanic thermometers with mercury-in-glass and electronic digital thermometers in cats and dogs. This might be due to the fact that tympanic muscle belongs to the core and not the shell. Tympanic temperature is a representation of the core temperature (Brinnel & Cabanac 1989, pp. 47-53).

Brunnel (2012, pp. 479-484) stated that a time lag between changes in core and subcutaneous temperatures could account for some of disparity obtained in temperature readings. A cursory look at the differences in the readings of infrared thermometer at forehead and opening of rectum signals that the accuracy of measurement will depend on the location. It suggests that taking reading at other parts of the body may yield closer readings to rectal temperatures. Gasim et al. (2013, pp. 1-5) had reported that thermometry infrared tympanic membrane thermometer is reliable and as accurate as axillary mercury-in-glass thermometer in humans, yet Yaron et al. (1995, pp. 617-21) reported that infrared tympanic thermometry did not agree with rectal temperature measurements. Both Chue et al. (2012, p. 356) and Rabbani et al. (2010, pp. 33-6) recorded agreement in readings with infrared tympanic thermometer and oral mercury-in-glass thermometers.

Body temperature measurement in growing broiler chickens with infra-red non-contact thermometer under the wings was closer to the values obtained with electronic digital thermometer via the rectum. Infra-red thermometer readings at the opening of the rectum and on the forehead had deviations of 3.63 and 3.79°C from electronic digital thermometer respectively. Taking body temperature with infra-red thermometer under the wings mimics the core body temperature in growing broiler chickens.

CONCLUSIONS

Thermometry with IR under wings gave a closer reading with ED thermometer. Accuracy of IR thermometer in broilers depends on the point on the body surface from which the reading is taken. Readings with IR under the wings mimic the core body temperature.

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