Veterinary Parasitology 171 (2010) 343–345

Contents lists available at ScienceDirect

Veterinary Parasitology

journal homepage: www.elsevier.com/locate/vetpar

Short communication

Thermal profile of rabbits infected with *Eimeria intestinalis*

Jaroslav Vadlejch[a], Ivana Knížková[c], Kateřina Makovcová[a], Petr Kunc[c], Ivana Jankovská[a], Karel Janda[b], Marie Borkovcová[d], Iva Langrová[a,*]

[a] *Department of Zoology and Fisheries, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 957, 165 21 Prague 6 – Suchdol, Czech Republic*
[b] *Department of Husbandry and Ethology of Animals, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 957, 165 21 Prague 6 – Suchdol, Czech Republic*
[c] *Department of Technology and Animal Breeding Technique, Institute of Animal Science, Přátelství 815, 104 00 Prague 22 – Uhříněves, Czech Republic*
[d] *Department of Zoology, Fisheries, Hydrobiology and Apiculture, Faculty of Agronomy, Mendel University in Brno, Zemědělská 1/1665, 613 00 Brno, Czech Republic*

ARTICLE INFO

Article history:
Received 21 December 2009
Received in revised form 20 March 2010
Accepted 26 March 2010

Keywords:
Rabbit
Eimeria intestinalis
Coccidiosis
Infrared thermography

ABSTRACT

In this study, infrared thermography (IRT) was assessed as a means of detecting the changes in body temperature in rabbit coccidiosis, as well as determining IRT used in imaging and measuring the regional changes in skin temperature that occur in the rabbits during this infection. Rabbits were inoculated with 5×10^4 or 1×10^5 oocysts of *Eimeria intestinalis*, respectively. The group of control animals remained non-inoculated throughout the study. All measured temperatures (rectal, ocular surface and auricle pavilion temperatures) dropped significantly ($P < 0.05$) in rabbits infected with 1×10^5 oocysts. This group of rabbits also showed a medium negative correlation in rectal temperature ($r = -0.49$), ocular surface temperature ($r = -0.49$) and auricle pavilion temperature ($r = -0.49$) and a small negative correlation in live body weight gain ($r = -0.22$) depending on the number of days elapsed from the time of infection exposure.

1. Introduction

Coccidiosis is a highly contagious sporozoal infection in rabbits, with a low prognosis for recovery. It is caused by 15 species of *Eimeria* and has been observed mainly in the gastrointestinal tract of rabbits (Coudert et al., 1993; Pakandl, 2009).

Symptoms of coccidiosis will depend on the state of the disease at the time of observation as well as on the species of *Eimeria*. In general, coccidiosis affects the intestinal tract, and symptoms are associated with it. In mild cases, only watery diarrhoea may be present, and if blood is present in the faeces, it is in small amounts, and in certain species only (Li and Ooi, 2009). Severely affected animals may have thin, watery faeces with considerable amounts of intestinal mucosa and blood. One of the signs of coccidiosis is hypothermia (Witlock, 1984; Koinarski, 1985; Pinard-van der Laan et al., 2009). That some degree of hypothermia existed during coccidiosis was recognized by Herrick (1950), who advocated the therapeutic use of heat for flocks during outbreaks of coccidiosis. Witlock et al. (1981) confirmed that changes in body temperature were slight until a determined point of fatal infection. The body temperature of birds just before death greatly decreased below the control values.

Infrared thermography (IRT) is a modern, non-invasive and safe technique of thermal profile visualisation. The thermographic method is also found in veterinary medicine and animal science (Kastberger and Stachl, 2003). In living organisms, changes in vascular circulation result in an increase or decrease of tissue temperature, which is then used to evaluate the situation in that area (Harper, 2000).

* Corresponding author. Tel.: +420 22438 2673; fax: +420 22438 2957.
E-mail address: langrova@af.czu.cz (I. Langrová).

0304-4017/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.vetpar.2010.03.037

The aim of the present study was to determine the changes in body temperature in rabbit coccidiosis, and to utilize IRT to image and measure the regional changes in skin temperature that occur in rabbits during an infection of coccidiosis. The pilot study was carried out to determine the effect of coccidiosis on rectal temperature, surface body temperature and overall condition of rabbits.

2. Materials and methods

A total of 18 rabbits (hybrid Hyla) aged 55–60 days were used. They were coccidian-free and reared under controlled conditions. They were divided into two treatment groups (A and B) and one control group (C) each containing 6 rabbits. The rabbits were kept individually in the cages and fed a supplementary commercial feed for 30 days before infection, after which only commercial non-supplementary feed was given.

The pure strain of *Eimeria intestinalis* (Laboratory of Coccidia, Institute of Parasitology, Biology Centre, ASCR, v.v.i.) was used for the experimental infection, and animals were inoculated per os. At day 0 of the experiment, the rabbits were inoculated with 5×10^4 (group A) or 10^5 (group B) oocysts. Uninfected animals served as a control (group C). Each day, from 5 to 20 dpi (days post-infection), faecal samples were collected from all the animals, and oocysts per gram (OPG) were estimated using the modified McMaster technique. Rabbits were sacrificed on day 21 post-inoculation. OPG, rectal temperature (by digital thermometer), ocular surface temperature, auricle pavilion temperature (by thermographic camera) and live body weight were monitored every day between 09:00 and 10:00 am. The microclimatic conditions of the experimental room (air temperature, ambient temperature, relative air humidity and air velocity) were recorded with the use of TESTO 415, TESTO 615 and pyrometer TPT60+.

Statistical analysis of both thermographic and biological data was conducted by the statistical software program Statistica.cz.

3. Results and discussion

The recorded microclimatic conditions were as follows: air temperature was from 21 °C to 25.3 °C, the ambient temperature from 17.1 °C to 24.9 °C, relative air humidity from 42.3% to 66.8%, air velocity was not recorded.

Inoculation of 10^5 *E. intestinalis* oocysts caused mortality in 3 animals after 9 days pi. Most animals died after 11 days pi. All infected animals excreted oocysts in the course of patency. The highest level of oocyst excretion was observed in group B, which was infected with 10^5 oocysts.

Oocyst shedding started on 6 dpi, and rose rapidly to a peak mean (on 10th day) of about 6×10^6 OPG (group A) and 10^7 OPG (group B), respectively. A decline of oocyst excretion was observed on day 11, thereafter it dropped rapidly. The animals of group B exhibited diarrhoea between 8 and 13 days pi. In group C, the uninfected control group, very little excretion was observed throughout the entire study period.

The values of rectal temperature, ocular surface temperature, auricle pavilion temperature and live body weight were evaluated on days zero and 10 (peak of infection) of the experiment. The changes of observed temperatures are illustrated by means of two thermograms (Fig. 1a and b).

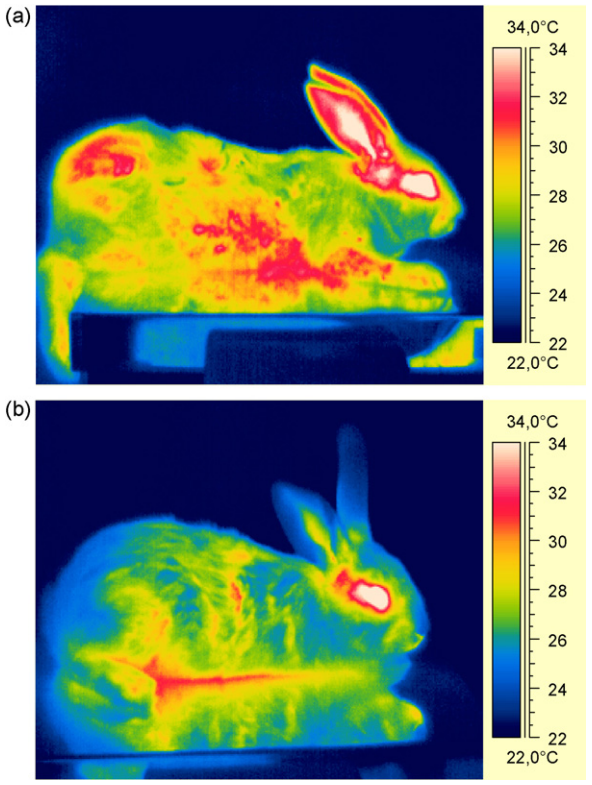

Fig. 1. (a) Thermal profile of a healthy rabbit and (b) thermal profile of rabbit infected with *Eimeria intestinalis* oocysts (10^5) (10th day of disease).

The results in the changes in temperature and in live body weight are presented in Table 1. Rectal temperatures in group B dropped significantly ($P < 0.05$). The difference between days zero and 10 was 0.5 K. Groups A and C did not show statistically significant differences in this observed parameter. The changes of rectal temperature in group B were significantly different ($P < 0.05$) when compared with

Table 1
Mean values of temperature [°C] and live weight [kg] on days zero and 10 in tested groups.

	Group A	Group B	Group C
Mean rectal temperature			
0 day	38.99 ± 0.55	38.85 ± 0.54^{a}	38.82 ± 0.51
10th day	39.21 ± 0.77^{A}	38.35 ± 0.46^{aAB}	38.93 ± 0.62^{B}
Mean ocular surface temperature			
0 day	35.96 ± 0.52	35.97 ± 0.39^{a}	35.95 ± 0.34
10th day	36.04 ± 0.39^{A}	35.18 ± 0.29^{aAB}	35.61 ± 0.36^{B}
Mean auricle pavilion temperature			
0 day	29.85 ± 2.24	30.83 ± 1.24^{a}	30.18 ± 1.31
10th day	28.05 ± 2.82^{A}	25.40 ± 2.45^{aAB}	27.77 ± 1.76^{B}
Mean live weight			
0 day	1.82 ± 0.19	1.88 ± 0.16	1.81 ± 0.18^{a}
10th day	1.81 ± 0.15^{A}	1.87 ± 0.21^{B}	2.19 ± 0.19^{aAB}

a: within group ($P < 0.05$).
A,B: between groups ($P < 0.05$).

groups A and C. A significant change ($P<0.05$) in ocular surface temperature was found in group B. Ocular surface temperature decreased to 0.75 K. Similar significant changes did not occur in groups A and C. The changes of ocular surface temperature in group B were significantly different ($P<0.05$) when compared with groups A and C. A significant change ($P<0.05$) in auricle pavilion temperature was again recorded in group B. The auricle pavilion temperature decreased to 5.43 K compared to the temperature recorded on day zero. No significant responses were observed in rabbits of groups A and C.

An increase in live body weight was found only in group C, both groups A and B showed growth depression. The difference in the parameter between groups C, A, and B was identified as statistically significant ($P<0.05$).

Group B showed medium negative correlation in rectal temperature ($r=-0.49$), ocular surface temperature ($r=-0.49$) and auricle pavilion temperature ($r=-0.49$) and small negative correlation in body live weight gain ($r=-0.22$) depending on day of disease. In groups A and C, medium negative correlation was not found.

The study confirms that *E. intestinalis* is pathogenic for rabbits and causes a high rate of mortality from inoculations of 10^5 sporulated oocysts. During the study, we observed that several experimentally infected rabbits exhibited signs of diarrhoea, which was self-limiting after 14 dpi. This is in accordance with earlier studies (Catchpole and Norton, 1975; Coudert, 1976). Symptoms were most evident between 8 and 13 days pi. This coincides with gametogenesis, which occurs 8–10 days pi (Cheissin, 1958).

Live body weight was influenced negatively by coccidiosis but it did not decrease in the inoculated groups (animals did not grow). Coudert et al. (1993) or Drouet-Viard et al. (1994) described a decrease in weight gain. Similar results were not recorded in our study.

The aim of the study was to compare temperature changes of different parts of the body during patent infection of *E. intestinalis* using an infrared camera. This study confirmed hypothermia in infected rabbits. Rectal temperature in rabbits with inoculation of 10^5 *E. intestinalis* oocysts decreased below the physiological range (38.6–40.1 °C). These data are confirmed by Witlock et al. (1981), who obtained similar results in chickens. The body temperature in the chickens also dropped below the control value.

Body surface temperature has not yet been investigated during coccidiosis in rabbits. The best method available to provide information on the temperature of the body surface and, in particular, on the dynamics of its changes, is IRT. IRT facilitates the localization of increased (inflammation or injury) or decreased heat (reduced blood flow or vasomotor tone). The patterns of a thermogram are affected by activities of the tissues, organs, and vessels inside the animal's body, and may be unique for a particular disease (Dunbar and MacCarthy, 2006).

In a pilot study of Ludwig et al. (2007), ocular surface temperature and auricle pavilion temperature were chosen for the evaluation of thermal status in rabbits. Ocular surface temperature and auricle pavilion temperature in rabbits with inoculation of 10^5 *E. intestinalis* oocysts decreased significantly and differed from other groups. Rabbits with severe infection of coccidiosis showed hypothermia and the total thermal profile of animals changed. We can conclude that *E. intestinalis* can significantly affect the homeostasis of organisms, and subsequently their thermal status.

In this study IRT detected significant changes in body surface temperature during coccidiosis. Infrared thermal measurements can be used very successfully in the prediction and detection of diseases, in research, as well as other applications in animal science.

Acknowledgements

We would like to thank Dr. Michal Pakandl for provision of parasite material. This study was supported by the Research Project of the Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, No. MSM 6046070901, and by the Research Project of the Institute of Animal Science, No. MZE 000240104. All experiments conducted with laboratory animals comply with the current laws of the country in which they were performed.

References

Catchpole, J., Norton, C.C., 1975. Coccidiosis in rabbits: experimental infections with *Eimeria intestinalis*. J. Protozool. 22, 49.

Cheissin, E., 1958. Cytologische Untersuchungen verschidener Stadien des Lebenszyklus der Kaninchencoccidien. I. *Eimeria intestinalis* E. CHEISSIN, 1948. Arch. Protistenk. 102, 265–289.

Coudert, P., 1976. Les coccidioses intestinales du lapin: comparaison du pouvoir pathogene d'*Eimeria intestinalis* avec trois autres *Eimeria*. C.R. Acad. Sci., Paris 282, 2219–2222.

Coudert, P., Licois, D., Provôt, F., Drouet-Viard, F., 1993. *Eimeria* sp. from rabbit (*Oryctolagus cuniculus*): pathogenicity and immunogenicity of *Eimeria intestinalis*. Parasitol. Res. 79, 186–190.

Drouet-Viard, F., Licois, D., Provôt, F., Coudert, P., Boivin, M., 1994. The invasion of the rabbit intestinal tract by *Eimeria intestinalis* sporozoites. Parasitol. Res. 80, 706–707.

Dunbar, M.K., MacCarthy, K.A., 2006. Use of infrared thermography to detect signs of rabies infection in raccoons (*Procyon lotor*). J. Zoo. Wildl. Med. 37, 518–523.

Harper, D.L., 2000. The value of infrared thermography in the diagnosis and prognosis of injuries in animals. In: Proceedings of Inframation, Orlando, USA, September 2000, pp. 115–122.

Herrick, C.A., 1950. The effect of coccidian on metabolism and temperature regulation of chickens. Poultry Sci. 29, 763.

Kastberger, G., Stachl, R., 2003. Infrared imaging technology and biological applications. Nebav. Res. Meth. Instrum. Comput. 35, 429–439.

Koinarski, V., 1985. Changes in the acid–base equilibrium of turkey poults infected with *Eimeria adenoeides*. Vet. Med. Nauki 22, 74–78.

Li, M.H., Ooi, H.K., 2009. Fecal occult blood manifestation of intestinal *Eimeria* spp. infection in rabbit. Vet. Prasitol. 161, 327–329.

Ludwig, N., Gargano, M., Luzi, F., Carenzi, C., Verga, M., 2007. Technical note: applicability of I.R. thermography to the measurement of stress in rabbit. World Rabbit Sci. 15, 199–206.

Pakandl, M., 2009. Coccidia of rabbit: a review. Folia Parasitol. 56, 153–166.

Pinard-van der Laan, M.H., Bedĭhom, B., Coville, J.L., Pitel, F., Feve, K., Leroux, S., Legros, H., Thomas, A., Gourichon, D., Repérant, J.M., Rault, P., 2009. Microsatellite mapping of QTLs affecting resistance to coccidiosis (*Eimeria tenella*) in a Fayoumi × White Leghorn cross. BMC Genomics 10, 31.

Witlock, D.R., 1984. Changes in moribund chickens as a result of *Eimeria necatrix* infection. J. Parasitol. 70, 433–435.

Witlock, D.R., Ruff, M.D., Chute, M.B., 1981. Physiological basis of *Eimeria tenella*-induced mortality in individual chickens. J. Parasitol. 67, 65–69.