



STUDIES ON REPRODUCTION OF ANIMALS AND BIRDS USING THERMAL IMAGING

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Abstract:

All objects and organisms on this earth radiate infrared waves in the electromagnetic spectrum. The method of scrutinizing these waves is called as “Thermal Imaging”. Evaluation of the temperature difference on the surface of the objects and organisms briefly describes the state and properties of the object under investigation. Thermal imaging finds its application in public and private sectors such as medical and military purposes, construction and manufacturing zones, zoological and ecological sections, other natural sciences. Application of thermal imaging is extended for exploring thermal physiology of captive breeding, which also has its involvement in poultry. Compared to any other methods, the results acquired by thermal imaging are far accurate due to its unique features. Thermography is secure, non-contact and non-persistent to spot any injuries, infectious diseases and inflammations to control reproduction (recognition of male fertility, detection of pregnancy and estrus). Analysis of effect of environmental factors on animal and bird behavior, localization of individual and their habitats, determination of animal and bird population, detection of flight paths and migration of birds, work on avian welfare can be examined by the above discussed methodology. Every invention has its own merits and demerits; similarly thermal imaging also has its own pros and cons.

Key Words: Thermal Imaging, Animal and Bird, Pregnancy and Estrus, Flight Paths, Migration & Welfare

1. Introduction:

Temperature distribution pattern on the surface of the object can be sensed in a safe, non-contact and non-persistent method by thermal imaging. Practical application of this method includes rescue operations, human and veterinary medicine and some other industrial and defence purposes. The main stress reducing advantage of thermal imaging is that, thermal imaging cameras can be used tenuously and the subject under the observation need not have to be constrained or segregated. Human body also emits infrared (IR) Radiation, thermal imaging cameras can be used for the effective measurement of the body surface temperature (which is due to temperature of internal tissues on the surface of the body) [1]. Temperature of the internal tissues is affected by the physiological process of the considered subject. This results in the increase or decrease of the blood flow. Heat produced during the inflammatory process is transferred to the adjacent tissues through enhanced capillary blood flow and is dissipate as infrared energy. Stability of temperature among different parts concludes the health condition of the body [19]. The temperature stability maintained parts of the object can be compared to identify the warmer spots, and the thermal deregulation caused, based on the knowledge of a given species [20]. Population size and their habitats can be sensed if a significant temperature difference exists between surroundings and the studied object. The core objective of this paper is to designate the difficulties faced by animals and birds while reproduction processes and also during their livelihoods, those glitches are short listed by using thermal imaging cameras.

2. Problems Faced by Animals during Reproduction:

The difficulties occurred during animal reproduction are mainly supported by anthropogenic materials, toxicants available in nature, stress, season of the year, nutritional levels, involvement of animal species, variability of genes and illness in animal[25]. These above stated problems results in abnormal reproduction and diagnosis in animals as shown in Fig. 1. An investigation can be put forth in a new stream, which is comprised of reproductive system and reproductive toxicology (Xenobiotics) [24]. Infertility, all facets of reproduction, stillbirth, teratogenesis and fetuses are the main problems which leads to death of an animal which are also known as reproductive dysfunction, undesirable development of baby inside the wound results in death or abortion. Morphologic changes, abnormalities in behavior, retardation of growth leads to failure in reproduction of the animal as shown in Figure 2.

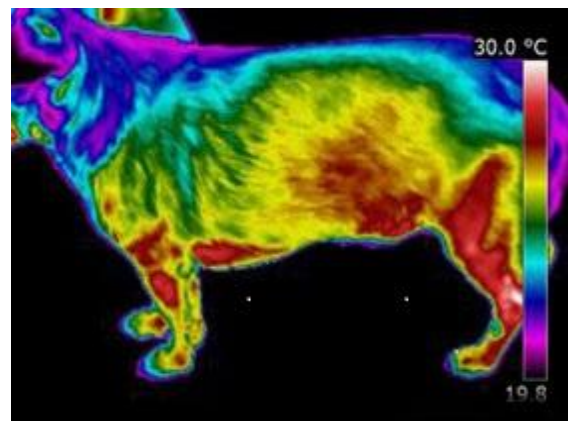


Figure 1: observation of dog under thermal imaging camera [25]

Toxic substances also cause infertility which effects reproduction process, by extracting the toxicant from the body, we can save the animal [26].

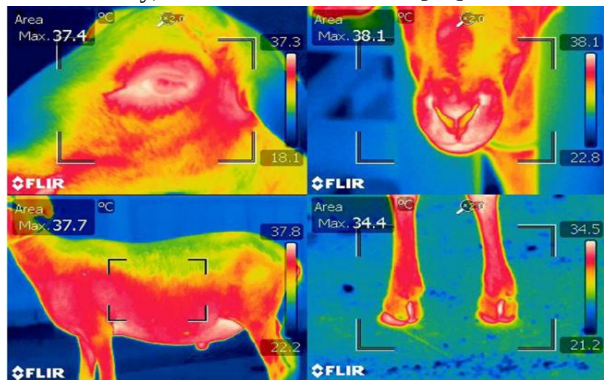


Figure 2: Thermal imaging camera showing various parts of an animal under the observation [26]



Figure 3: Observation of ostrich under thermal imaging camera [17]

Heat distribution on ostrich body can be observed in Fig. 3. Red spot on the ostrich body designates those as the hottest sites [17].

3. Case Studies on Animals are Listed Below:

Table 1: Diseases diagnosis [5]

Name of the Author and Experimental Year	Animal Chosen for Examination	Diseases Detected Using IRT	Observation Regarding the Experiment Using IRT
1. Dunbar et al (2009)	Mule deer (odocoileus hemionus)	Foot and mouth disease	gradual increase in Temperature if the disease is detected
2. Arenas et al (2002)	wild Spanish ibex (capra pyrenaica) [3]	Diagnose sarcoptic mange	need to collect skin samples for analysis
3. Dunbar and marccarthy (2006)	Raccoons (Procyonlotor)	Rabies infection	distinguishes infection as stages in animals

Fluctuation of body temperature, recognition of infectious foot and mouth disease in mule deer's [9] and also acknowledged rabies infections in Raccoons [8]in stages as mentioned in the table (1) are some of the common diseases in wild animals which can be simply spotted by the method called thermography.

Table 2: Control of reproductive processes [4]

Name of the Author and Experimental Year	Animal Chosen for Examination	Diseases Detected Using IRT	Observation Regarding the Experiment Using IRT
1. Hilsberg-merz(2008)	Asian elephants and black rhinoceros[10]	Diagnose ovulation	Rise in temperature in female reproductive organs
2. Hilberg (1998)	Black rhinoceros	Late stages of pregnancy	pregnancies are identified
3. Durrant et al (2006)	Giant pandas	pseudopregnancy	pregnancies are recognized

Steady rise in temperature level in the female reproductive parts and development of ovulation in male of both Asian elephants and black rhinoceros as describe in the table (2) can be recognized by Thermal Imaging [15]. Thermography is a highly favorable tool for monitoring the reproductive cycle in animals when compared to other high precision methods which are problematic to exercise. Thermal imaging is also used to identify of pregnancy and pseudopregnancy in Giant pandas.

Table 3: Thermoregulation [1]

Name of the author and experimental year	Animal chosen for examination	Observation regarding the experiment using IRT
Speakman and ward(1998)	1. Red fox(vulpes vulpes)[10] 2. Arctic fox(alopex lag) 3. Kit fox(vulpes macrotis)	Determined the heat transfer in three fox species at different ambient temperature(from 25-33 °c)
Kuhn and meyer (2009)	1. Eurasian otter (lutra lutra) 2. Tropical giant otter (pteronura brasiliensis)	Body temperatures have been recorded in selected otter species.
Klir et al (1990)	Mongolian gerbil (meriones unguiculatus)	Body temperature was observed for Mongolian gerbil.
Tattersal and cadena (2010)	Toco toucan (ramphastos toco)	Changes in body temperature were analyzed.
Lancaster et al (1997)	Egyptian Fruit bat (Rousettus)	Temperature alteration among wings and

	aegyptiacus)	ambient air were unimportant.
Mccafferty et al (1998)	Barn owl (Tyto alba)	Feet and the lower surface of the wings were observed to be hottest areas of their bodies.
Sumbera et al (2007)	African mole rats (fucumys mechowii) and (heliophobus argenteocinereus)	Heat dissipation to the environment and changes in body temperature have been listed out.
Nakayama et al (2005)	Rhesus monkeys (macaca mulatta)	Decrease in nasal temperature is the indication of negative emotional state in nonhuman primates
Mccafferty (2007)	Gaint Honeybee (Apis dorsata)	Increase in the temperature of its skeletal muscles to prepare for various types of physical activity
Hristov (2008)	Brazilian free-tailed bats (tadarida brasiliensis)	Gender and age variations are keenly observed and forging behavior were recorded.

In all fox species, some of the body parts like nose, lower legs, paws and the front of the ears where important thermoregulatory [21] surfaces which can be detected by Thermal imaging. Giant otters are one of the animals which lose heat from the complete body, from the tail portion also [22]. Variations in the bill temperature in the toco toucan, changes in the body temperature of young and adult hippopotamuses was detected by thermography as discussed in table (3) and also thermal imaging is used to detect wing temperature in flying bats[13].

Table 4: Detection of animal and estimation of population size [11]

Name of the author and experimental year	Animal chosen for examination	Observation regarding the experiment using IRT
Graves et al (1972)	White –tailed deer (odocoileus virginianus)[6]	Population size was calculated throughout the day.
Hodnett (2005)	White-tailed deer in urban areas[16]	Species density was estimated.
Kissell and tappe (2004)	White-tailed deer [7]	Beneath the dry circumstance Animals in the lowland deciduous forests have been noticed.
Mayle et al (1999)	Deer [12]	Naturally veiled newly born deer calves have been spotted underground
Ditchkoff et al (2005)	White –tailed deer fawns[7]	Neonatal fawns were identified
Boonstra et al (1994)	1. American red squirrel (tamiasciurus hudsonicus) 2. Arctic ground squirrel(spermophilus parryii) 3. Snowshoe hare (lepus americanus) 4. Meadow jumping mouse (zapus hudsonicus)	The existences of red squirrels, snowshoe hares, meadow hopping mice, where effectively detected.
Boonstra et al (1995)	1. Pileated woodpecker (dryocopus pileatus) 2. Bufflehead (bucephala albeola) 3. Mallard(anas platyrhynchos) 4. Green-winged teal(anascrecca) 5. Great –horned owl(bubo virginianus) 6. Lapland longspur (calcarius lapponicus) 7. Pectoral sandpiper (calidris melanotos)	Nests of cavity and burrow-nesting of birds were detected.
Perryman et al (1999)	Eatern pacific gray whales(Eschrichtius robustus)	Gray whales swimming speed and migration rates are recognized.
Sabol and Hudson (1995)	Gray bat (myotis grisescens)	for counting bats semi-automated system was established

As mentioned in the Table 4, Thermal Imaging is used to determine population size, to spot white tail deer in the urban zones [16]. The existence of snow shoe hare, meadow jumping mice, red squirrels and the activity in nest

or burrows of arctic ground squirrel where effectively sensed. Thermography was very advantageous when vegetation cover was nominal [14].

4. Case Studies Related to Wild Birds Using Thermal Imaging Cameras [20]:

Allison has contributed in congregation of information related to thermography on wild birds. He has poised information from different sources as enumerated below:

Desholm (2003) continued his research on ten species at offshore wind farm at a distance of 3000metres using a Thermovision IRMV 320Volts Thermal imaging camera. Boonstra et al (1995) investigated on nine species which are located at different places like sitting on the trees, which are in an open habitat and at Arctic tundra. He used a Thermovision 210 camera for the study. Mills et al. (2011) proposed a study on clapper Rail *Rallus longirostris* in a Tidal marshes habitation. In this process he continued with a Thermal-Eye 250D and X200xp, L-3 communication infrared product to detect the irregularities.

Galligan et al. (2003) investigated on two *Ammodramus* sparrows located in grassland at a distance of 3-5 meters from therma CAM PM575, FLIR System. Tillmann (2009) had continued his research on Night-time roosting and anti-predation behavior of Grey Partridge *Perdix* at Arable land using a Palm IR-250D and Raytheon for his study which was conducted at a distance of 250meters. Kuwae (2007) (Nocturnal behavior: defection rate) had continued his research on Kentish Plover *Charadrius alexandrinus*. He had selected Intertidal flat as habitat and used a therma CAM SC-3000 with Telescopic lens, FLIR system.

Benshemesh and Emison (1996) (Aerial survey on nests) performed the experiment on Malleefowl *Leipoa ocellata*. He conducted the experiment in forest at a distance of 305 meters using a Daedalus 1240/60 scanner. Calbrade and Henderson (2009) selected bird flight height for wind farm survey in European Nightjar *Caprimulgus europaeus* for investigation. They conducted the experiment in forest at a distance of 100-200meters using P640, FLIR systems. Gauthreaux and Livingston (2006) continued Migration counts. They used Radiance 1, Amber and Raytheon cameras at a distance of nearly 2800meters.

Zehnder et al (2001) continued his research of nocturnal migration counts in coastal habitation. They used LORIS, IRTV-445, and Inframetrics at a distance of 3000metres. Mattsson and Niemi (2006) selected Oven bird nests and fledglings at forest site using NIGHTSIGHT, PalmIR 250, and Raytheon System Mitsubishi IR-M600. He continued the experiment at a distance of 30metres from the bird. Garner et al. (1995) have chosen Aerial survey wild Turkey *Meleagris gallopavo* as the specie. They conducted his study in Uplands using 2000 A/B FLIR System at a distance of 398meters from the object under observation [20].

5. Limitations:

As mention above thermography is promptly emerging equipment which has created an enormous prospects in research of animal and bird reproduction, but lags behind due to few drawbacks as listed below:

Weather conditions: fluctuations in climatic changes like air wetness, rainfall, breezing and solar radiation will alter the surface temperature of the object or an organism which is under examination. Remedies for the above mentioned drawback is thermal imaging cameras can be used in indoor safely; it can have accurate outcomes during night time [5]. Distance between the object and the thermal imaging camera: précised outcomes using thermography on animal and birds reproduction are limited to certain range of distance only. Remedies for the above mentioned drawback is distance should be short ranged scrutinizing the objects using thermal imaging camera [2].

Physical properties of the animal coat: the temperature on the outer surface of the body will vary due to thickness of the skin, hairs and feathers. This abstracts effect in visibility of thermography [23]. Remedies for the above mentioned drawback is to obtain remarkable outcomes using thermal imaging as possible as we can, we need to clean the skin surface and dry it to get proper results. Physical activity: animals and birds while running, eating, hunting and sleeping will release heat, which results in rise in temperature of outer surface of the body. Stresses in animals and birds will also be a consequence in fluctuation in temperature. Blood transmission is one of the factor which leads to incorrect outcomes [18]. Remides for the above mentioned drawback is we need to place the animal or bird which is to be examined in separate laboratory and see the animal is in static position [5]. Cost: The device used in thermography is quite cost consuming.

6. Conclusion:

Based on review, we plan to use this thermal imaging in animal and bird reproduction to detect male fertility, detection of pregnancy and estrus, Analysis of effect of environmental factors on animal and bird behavior, localization of individual and their habitats, determination of animal and bird population. Infertility, all facets of reproduction, stillbirth, teratogenesis and fetuses are the main problems which leads to death of an animal, these kinds of problems can also be examined and observed under the thermal imaging camera. Case studies related to conventional usage of thermography in animal and bird reproduction and their behavior is also enlightened. Finally few drawbacks in using thermal imaging cameras are also identified and discussed.

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