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Analysis of Solar Collector Surface to Air Flow Thermal Transfer Using Solid State Sensors and Microcomputer Interfacing

Rudolph J. Eichenberger
Southern Arkansas University

RANGE EXTENSION OF THE PORCUPINE *(ERETHIZON DORSATUM)* INTO SOUTHWEST ARKANSAS

Both Dodge (1982) and Hall (1981) report that the range of the porcupine *(Erethizon dorsatum)* extends into central Texas and Oklahoma and eastern Kansas but none have been reported in Arkansas.

Between 1 December and 15 December, 1984 a porcupine was accidentally killed 2 km north of the town of Ben Lomond in Sevier County, Arkansas (R29W, T10S, Sec. 10). This female specimen weighed 7.6 kg (16.8 lb) and measured 94 cm in total length. This is the first documented occurrence of a porcupine in Arkansas and may indicate a range expansion of the species.

The specimen was recovered by Arkansas Game and Fish Commission personnel and has been donated to the Museum of Natural History at the University of Arkansas.

ACKNOWLEDGMENTS

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JOSEPH D. CLARK, Arkansas Game and Fish Commission, 2 Natural Resources Drive, Little Rock, AR 72205.

NOTES ON THE DEATH OF AN INTRODUCED BLACK BEAR IN ARKANSAS

Between 1959 and 1967, the Arkansas Game and Fish Commission transplanted 254 black bear *(Ursus americanus)* from northern Minnesota and Manitoba to western and northwestern Arkansas. Releases were made in the White Rock and Piney Creek Wildlife Management Areas (WMAs) in the Ozark National Forest and in the Muddy Creek WMA in the Ouachita National Forest (Rogers 1973). Since that time the number of black bears has increased dramatically (Pharris 1981). Arkansas' first modern-day bear hunt was held in 1980.

On September 20, 1984 a 150 kg (330 lb) female black bear was killed in Johnson County under a depredation permit. The bear had been causing extensive damage to fruit trees and other property and attempts to live-trap the animal were unsuccessful. After the bear was killed it was noted that she was wearing an aluminum ear tag.

After reviewing a report prepared by Rogers (1968) it was determined from the ear tag number that this individual bear had been captured near Ely, Minnesota and released on Piney Creek WMA on July 28, 1968. At the time of her release the animal weighed 65 kg (143 lbs) and was classed as a mature animal. She was killed only about 21 km (13 mi) west of her original release site.

According to these data, this animal was a minimum of 17 years of age. Although Pelton (1982) states that bears in the wild may reach ages of 15 to 20 years, the occurrence of this 17 year old female is noteworthy because it may be indicative of the capability of some Arkansas habitats to support bears. Although Rogers (1973) reported movements of restocked bears in Arkansas of up to 418 km (260 mi), apparently this female was able to survive for a long period of time within a relatively small area.

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JOSEPH D. CLARK, Arkansas Game and Fish Commission, 2 Natural Resources Drive, Little Rock, AR 72205.

ANALYSIS OF SOLAR COLLECTOR SURFACE TO AIR FLOW THERMAL TRANSFER USING SOLID STATE SENSORS AND MICROCOMPUTER INTERFACING

Previous studies investigated dual functioning collectors (Eichenberger, Energy Conv. & Mgt., 20:197-199, 1980) and efficiencies of thermal conversion for certain solar collectors (Eichenberger, Arkansas Academy of Science Proc., XXXVII, 82-83, 1983). The first study listed above was done in a northern climate and indicated the insulation property of a vertical collector installed in a single glazed window was about ten times more cost effective in reducing heat loss than in solar energy collection. The second study listed above found that aluminum screen collector surfaces painted flat black had the highest conversion efficiencies and that a double glazed polycarbonate cover plate was the most effective.

The purpose of this study was to determine the efficiencies of different collector air flow patterns using integrated circuit solid state linear temperature sensors interfaced to a microcomputer.

A Radio Shack Color II microcomputer with a thermal printer was connected to four National Semiconductor LM335Z temperature sensors placed inside the solar collectors at selected positions to periodically measure the temperature. The data was then analyzed for hot spots on the collector surface which would indicate low air flow rates at those positions.

The temperature sensors were interfaced to the microcomputer through the joystick ports. The Radio Shack Color II microcomputer has built-in analog to digital converters; however, the investigator constructed amplification and calibration circuits to permit interfacing and data collection, see Figure 1 for circuit schematics. A LM 324 quad operational amplifier was used with the four sensors. A modified circuit with different variable resistors and temperature sensors was used instead of that reported in the literature (Barden, TRS-80 Models I, III, and Color Computer Interfacing Projects, 255, 1983). The manufacturer reported a temperature range of −40 degrees Celsius to +100 degrees Celsius for the LM335Z solid state temperature sensors and a typical sensitivity of ± 1.0 degree Celsius to ± 2.0 degrees at extended temperatures. The investigator found a sensitivity of ± 2.0 degrees Celsius, possibly because of the circuit or microcomputer A/D limitations. The microcomputer had a numerical output range of 0 to 48 for the temperature calibration range of the sensor, 0 to 100 degrees Celsius. The investigator also found some circuit instability at low temperatures which was most likely a result of the inability to recalibrate correctly at extended low temperatures. This problem was partially resolved by recalibration of each sensor before the daily data collection period. Each of the four sensors were initially calibrated with a mercury-in-glass thermometer in contact with a water surface. Care was taken not to submerge the sensors in water even though the electrical contacts had been sealed with PVC cement. Data collected with this method was used to produce calibration curves for each sensor. The curves were found to be basically linear and nearly coincident so that, within the ± 2 degrees Celsius resolution of the system, the same BASIC program was used to calculate the temperatures.

The BASIC program is listed as follows:

```
10 REM - TEMP SENSOR
20 A=JOYSTK(Ø)
30 B=JOYSTK(1)
40 C=JOYSTK(2)
50 D=JOYSTK(3)
60 T1=(48-A)/.46
70 T2=(48-B)/.46
80 T3=(48-C)/.46
90 T4=(48-D)/.46
100 PRINT #-2, "A IS";A
110 PRINT #-2, "B IS";B
120 PRINT #-2, "T1 IS";T1
130 PRINT #-2, "T2 IS";T2
140 PRINT #-2, "C IS";C
150 PRINT #-2, "T3 IS";T3
160 PRINT #-2, "D IS";D
170 PRINT #-2, "T4 IS";T4
180 PRINT #-2, "REPEAT"
200 FOR Z=Ø TO 5
205 FOR S=Ø TO 59
210 FOR T=1 TO 39Ø
220 NEXT T
225 NEXT S
230 NEXT Z
240 GO TO 1Ø
```

Steps 200 to 230 provide a timing loop so the microcomputer collected data and printed it on the thermal printer in about five minute intervals.

Three solar collectors were used in the experiment. Collectors C1 and C2 were identical in size, 1.22 meter by 1.22 meter outside dimensions with aluminum screen collector surfaces raised 2.5 cm above a 2.5 cm thick styrofoam insulation board covered with aluminum foil. The aluminum screen and aluminum foil were painted flat black with inexpensive carbon and silicate pigment pain. Neither collector was provided with additional sidewall insulation. The sidewalls were 5.0 cm thick wood. Both collectors had one air inlet and one outlet in the top rear of the collector. The inlet was on the right and the outlet on the left of a baffle running the length of the collector which forced the air from back through the right screen toward the transparent cover plate, and then the air was pulled back through the left screen and out by a blower. The blowers were rated by the manufacturer at 0.99 cubic meter per minute of free air. The blower installed on collector C1 was measured to produce 0.59 cubic meter per minute while that installed on collector C2 was measured to produce 0.70 cubic meter per minute. Measurements were made with a Bacharach Florite mechanical air flow meter. The collectors had different covers but the collector surface to cover distance was 3.5 cm on both. Collector C1 had a corrugated filon layer over a polyvinyl film while collector C2 had a doubled glazed polycarbonate cover separated by 0.5 centimeter. Both collectors were installed on a south-facing wall 13 degrees from the vertical.

Collector C3 was larger, 1.22 meters wide by 2.44 meters long with an aluminum screen in an undulating wave configuration contacting at five points over a 2.5 cm thick insulation board covered with aluminum foil. Both the screen and the aluminum foil were painted with inexpensive flat black paint containing carbon and silicate pigments. C3 had a cover of single glaze corrugated filon. Air was input on the cover plate side of the aluminum screen along the corrugation gaps at the top and bottom and then pulled through the screen and out the back of the collector by an exhaust fan with a measured installed flow rate of 2.17 cubic meter per minute. C3 was installed on a south-facing wall 10 degrees from the vertical.

The average efficiencies of the three collectors are displayed in Table 1. Efficiencies were calculated by dividing the thermal power output by the solar power input. Solar power input was measured with a Crystal Products meter.

Results indicate the collector with the double glazed polycarbonate cover and flat black aluminum collector surface is the most efficient and delivered the greatest thermal power output per square meter of surface area. Somewhat surprising was the second most efficient collector. This collector had only a single glazed filon cover and therefore was less costly to construct. The air flow input from front cover through the screen and out the back of the collector apparently was the reason for its surprisingly high performance.

The solid state integrated circuit temperature sensors were placed inside the collectors as sketched in Figure 2. The subscript (o) indicates the sensor was on the outside of the collector screen and subscript (i) indicates the sensor was on the inside of the screen.

Analysis of the temperatures taken over several days at the four locations in each of the collectors, indicated that higher temperatures occurred on the cover plate side of the screen and lower temperatures were to the inside of the screen between the foil and screen. Generally the temperatures were lower near the input position and higher near the output position as one would expect. Better heat transfer is obtained if the inlet air enters between the cover plate and collector screen and is pulled through the screen and out the insulation board in the rear of the collector. The collectors were found to have greater efficiencies if the exhaust air was taken from the top of the collector rather than from the bottom of the collector even though the same exhaust fan was used in both cases. The comparison was made by rotating the collectors 180 degrees about a horizontal axis.

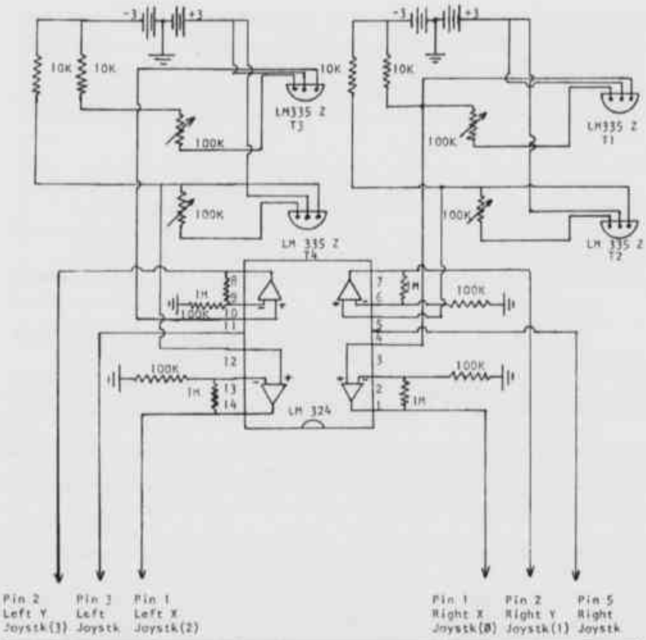

Figure 1. Temperature sensor interface to Radio Shack Color II microcomputer.

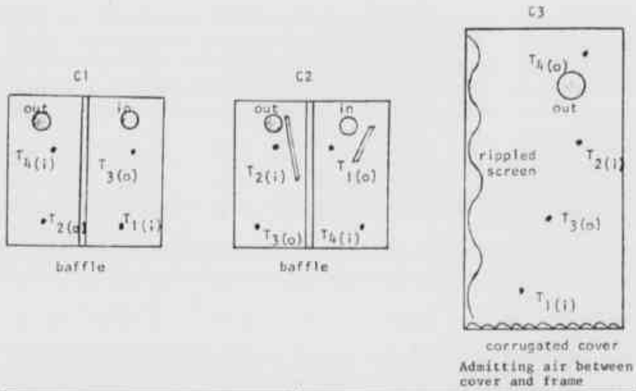

Figure 2.

Table 1.

COLLECTOR	AVERAGE EFFICIENCY	AVERAGE THERMAL* POWER OUTPUT/m^2	COVER PLATE
C1	40%	175 watt	Filon-Vinyl Film
C2	60%	268 watt	Double Glaze Polycarbonate
C3	59%	243 watt	Single Glaze Filon

*Averages were for clear to partly cloudy days from February 12 to April 4, 1985. All collectors were operated and data collected concurrently on measurement days.

RUDOLPH J. EICHENBERGER, Physics-Engineering Dept., Southern Arkansas University, Magnolia, AR 71753.

FALL DEER FOOD SELECTION IN THE OUACHITA NATIONAL FOREST

A five-year study of fall food habits was undertaken in an attempt to fill substantial gaps in our knowledge about white-tailed deer populations in the Ouachita National Forest. Previously, no such data were available for the Ouachitas. In nearby Clark County, Adams and Harris (Seventh Ann. Southeast Deer Study Group Conf., 1984, Unpubl.) identified 46 food items in deer rumina. Of these, the dominant items were acorns of white oak *(Quercus alba)* and red oak *(Q. falcata, Q. nigra, Q. phellos),* Japanese honeysuckle *(Lonicera japonica),* fungi, dry leaves, and red mulberry *(Morus rubra).* Studies by Harlow et al. (Harlow, J. Wildl. Manage., 28:562-567, 1984) and Lay (Lay, J. Wildl. Manage., 29:370-375, 1965) have also shown that fruits are an important constituent of fall deer diets throughout forests in the South.

The 637,520-ha Ouachita National Forest, located in west central Arkansas and southeastern Oklahoma, is intensively managed for timber and wildlife. The terrain varies from nearly flat to rolling hills and steep ridges. Soils are of sandstone, shale, novaculite, and chert origin and range from low to moderate in productivity for pine timber. Shortleaf pine *(Pinus echinata)* and loblolly pine *(Pinus taeda)* predominate in association with a hardwood midstory of white oak, northern red oak *(Q. rubra),* black oak *(Q. velutina),* southern red oak *(Q. falcata),* blackgum *(Nyssa sylvatica),* post oak *(Q. stellata),* hickories (*Carya* spp.), and sweetgum *(Liquidambar styraciflua).* Common understory species include blueberry (*Vaccinium* spp.), poison ivy *(Rhus radicans),* dogwood *(Cornus florida),* red maple *(Acer rubrum),* with young sprouts of hickories, oaks, and blackgum. Mixed red oak-white oak-hickory stands are common on north facing slopes and along stream bottoms.

During November of 1979 and 1981-84, rumina from 64 hunter-killed deer were collected throughout a 7-county area (Garland, Montgomery, Perry, Polk, Sebastian, Scott, Yell). Rumen contents were preserved in 10% formalin for later study. Yearly sample size ranged from 6-24. Hunter participation was encouraged by offering to photograph cooperators with their kills and later mailing a photo to those who made deer available for the study.

Using the techniques of Harlow and Hooper (Harlow, Proc. Ann. Conf. Southeast. Assoc. Fish and Wildl: Agencies, 25:18-46, 1971), rumen samples were washed through a 9.51 mm sieve. Selection of this mesh size was based on Harlow and Hooper's findings that smaller mesh sizes resulted in excessive processing time while use of a 9.51 mm sieve gave the true occurrence for 68% of food items. Food items were sorted and their volumes determined by the water displacement method. Any item accounting for < 1% was recorded as a trace.

Mean volume (%) and frequency of occurrence (%) by food item are presented by year in Table 1. Two trends are readily apparent. First, although many food items were present in small amounts, relatively few items accounted for most of the volumes. Second, there was great variation among years. Acorns for example, were found to average 65% by volume and were present in 83% of the samples taken in 1979. However, no acorns were found in 1983, and few (5%) in 1984, years of poor hard mast crops. Sumac seed heads were likewise important in most years, occurring in 100% of rumina sampled in 1982 and averaging 37% of the volume. In other years, sumac averaged at least 13% by volume and occurred in 33% of samples.

Greenbriar was found in 63-100% of our samples, including all rumina sampled in 1983 and 1984. About half (41%, 53%) of average rumina volumes for these years consisted of greenbriar leaves and stems. Use of greenbriar coincided with the lack of hard mast in these years indicating

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