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Flat Plate Solar Thermal Collectors: A Comparison of Efficiencies of Various Collector Configurations

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Achaearanea and *Prolinyphia* species are web builders that were found hanging in their webs at the top and along the walls of the tunnels apparently trying to trap small flying insects. Specimens of *Achaearanea porteri* (Banks) collected during this study represent the only known localities for this spider from the Ouachita Mountain area and only the second collection of this species in the state. Interestingly, the only other report of this spider from Arkansas was by Barnett (1970) who found this species utilizing similar habitat within Mansell Cave in Randolph county.

Members of the genus *Amaurobius* were found primarily under stones and in rock fissures or wall crevices. Dark areas of the tunnels near the entrances were preferred. Specimens of *Amaurobius ferox* (Walckenaer) collected during this study represent a new state record.

Assistance from Darrell Heath and Teresa Beggs in collecting specimens is gratefully acknowledged.

Table. Data concerning spider collections from mine tunnels.

Taxon	Date	County	Distance in Meters From Entrance
Amaurobius ferox (Walck.)	12/20/82	Garland	0-8
Dolomedes vittatus (Walck.)	1/08/83	Polk	0-8
Achaearanea porteri (Banks)	1/18/83	Garland	0-8
Amaurobius ferox (Walck.)	2/20/83	Garland	17-50
Prolinyphia marginata (Koch)	2/20/83	Garland	0-8
Achaearanea porteri (Banks)	2/20/83	Garland	0-8
Achaearanea tepidariorum (Koch)	2/20/83	Garland	0-8
Achaearanea tepidariorum (Koch)	2/20/83	Montgomery	0-8
Dolomedes vittatus (Walck.)	2/20/83	Montgomery	0-20
Amaurobius ferox (Walck.)	2/20/83	Montgomery	0-50
Dolomedes vittatus (Walck.)	2/12/83	Polk	0-50
Dolomedes vittatus (Walck.)	2/12/83	Polk	0-50
Dolomedes tenebrosus (Hentz)	3/26/83	Polk	0-10
Dolomedes vittatus (Walck.)	3/26/83	Polk	0-10
Amaurobius ferox (Walck.)	3/26/83	Polk	0-10

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FLAT PLATE SOLAR THERMAL COLLECTORS: A COMPARISON OF EFFICIENCIES OF VARIOUS COLLECTOR CONFIGURATIONS

In a previous study, collectors were installed vertically in a south-facing single glazed laboratory window. The dual functions were as a thermal solar collector and as an insulator for the window. Results included an energy saving from the insulation property of approximately 19 dollars per year and an experimental solar energy collection income of approximately 2 dollars per year (Eichenberger, Energy Conv. & Mgt., 20:197-199, 1980).

The purpose of this study was to compare the efficiencies, energy collected, and construction cost for various practical collector configurations and materials.

The inside configuration and materials used in converting solar radiation to heat energy were varied for comparison. Cover plate materials were also varied for comparison. Materials tested were relatively inexpensive building materials suitable for self-construction and installation. The material cost per thermal power delivered (watt) was also calculated since this is an important consideration in solar utilization.

Two solar collectors were constructed to provide a side-by-side test situation. The collectors were both 1.22 meter by 1.22 meter outside dimensions. One collector served as the control and the other as the experimental model on which the internal material and cover plates were changed. Solar insolation was measured with a meter which was calibrated using a reference source on the same date and time and extrapolated for the same latitude (Anderson, Solar energy; fundamentals in building design, p. 292, 1977). Each collector was fitted with an electric blower rated at 16 watts and 0.99 cubic meter per minute of free air; it delivered a measured 0.42 cubic meter per minute of air flow when connected to the collector. The flow rate of the blower was measured with a Dwyer flow meter. This measured rate was compared with a mechanical anemometer and a fan. Results of the two flow rate measurements were with 5%. Ambient temperatures and output air temperatures were measured. Heat delivered was calculated and the input solar energy was measured with the meter and used in calculating the efficiencies.

In the first stage of the experiment, both collectors were fitted with identical double glaze polycarbonate covers. The inside absorber configurations were changed for comparison of efficiencies and thermal power produced. The control collector had aluminum screen placed 2.5 centimeters above a styrofoam insulation board in the back. Both the aluminum screen and the insulation board were painted flat black with inexpensive carbon and silicate-based paint. Air was forced from the back through the screen toward the cover plate, and then pulled back through the screen absorber by a fan and a baffle and out the back (see Fig. 1). The experimental collector was also fitted with a 2.5 centimeter thick styrofoam insulation panel covering the back. Then 2.5 centimeter high styrofoam channels were attached to the insulation board. These channels were designed to produce a serpentine air flow across the collector (see Fig. 2). The entire board and channels were covered with aluminum foil and

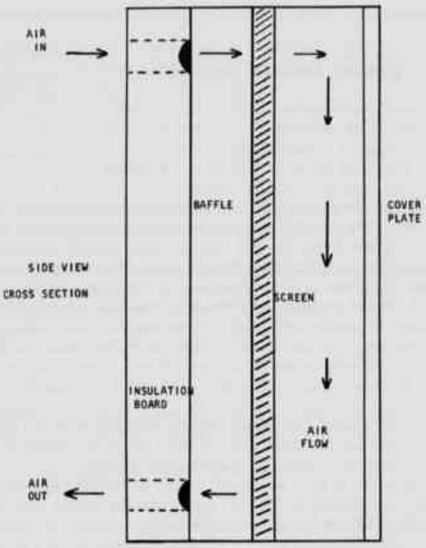

Figure 1.

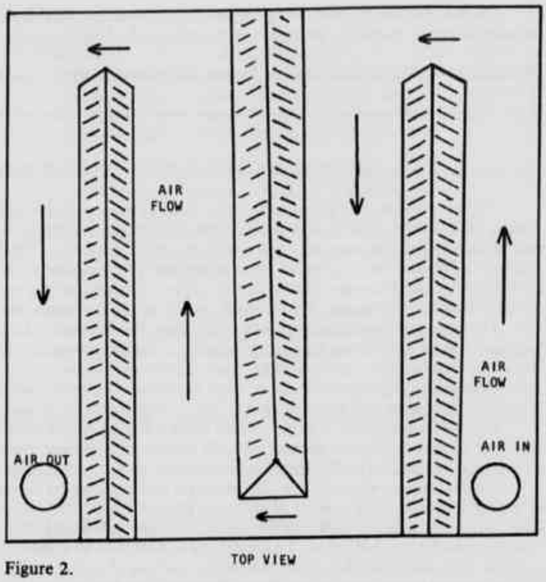

Figure 2.

Table 1. Interior Light to Heat Conversion Materials with Identical Double Glaze Polycarbonate Covers

Material	Average Efficiency	Average Thermal Power/m2
Black Aluminum Screen*	35%	237 watts ± 5 watts
Black Aluminum Foil Channeled	32%	205 watts ± 5 watts
Black Aluminum Screen*	35%	194 watts ± 5 watts
Black Steel Roofing	24%	129 watts ± 5 watts

* Indicates control collector unit operating during the same time period.

Table 2. Various Cover Plates with Identical Interior Black Aluminum Screen Absorbers

Material	Average Efficiency	Average Thermal Power/m2
Double Glaze Polycarbonate*	37%	237 watt ± 5 watts
Single Glaze Styrene Acrylonitrile	29%	183 watts ± 5 watts
Double Glaze Polycarbonate*	37%	194 watts ± 5 watts
Single Glaze Filon (Fiberglass Reinforced Resin)	26%	172 watts ± 5 watts

* Indicates control unit.

Table 3.

Black Aluminum Screen Absorber-Double Glaze Polycarbonate Cover	21¢/watt
Black Steel Roofing Absorber-Double Glaze Polycarbonate Cover	36¢/watt
Black Aluminum Foil Channeled Absorber-Double Glaze Polycarbonate Cover	21¢/watt
Single Glaze Styrene Acrylonitrile-Black Aluminum Screen Absorber	18¢/watt
Single Glaze Filon-Black Aluminum Screen Absorber	15¢/watt

painted flat black. The second experimental configuration was assembled with corrugated steel roofing painted flat black as the absorber plate. Air was made to flow over the top of the roofing and below the roofing and between the styrofoam insulation board.

The second part of the experiment compared different materials commonly available as cover plates with identical flat black aluminum screen absorbers as described earlier.

A materials cost analysis was done for each collector configuration to find the cost per unit of thermal power delivered. The analysis excluded labor costs. The results are displayed in Table 3.

Flat black aluminum screen absorber delivered the highest conversion from solar light to heat efficiency of about 35% and the highest average thermal power of about 240 watt/m². Double glazed polycarbonate was the most efficient cover plate, as expected, and delivered the highest thermal power. Of the single glazed material tested, styrene acrylonitrile delivered slightly higher efficiency and thermal rating. Collector efficiencies were higher on lower ambient temperature days, as one would expect, because of radiation energy losses from the collector proportional to the fourth power of the absolute temperature and lower collector temperatures on those days. Results were averaged over a minimum of five days to reduce these variations, and values reported in Tables 1 and 2 compared experimental with control units during the same time period.

The materials cost per delivered unit of thermal power was lowest for the single glazed filon cover plate at about 15¢/watt with the black aluminum screen absorber material.

Further study is planned using polyethylene film as one glazing and a rigid material such as filon as the second glazing to cut costs and increase the effectiveness, therefore promoting the utilization of solar energy.

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NEUTRAL SUGARS IN SELECTED PIT VIPER, ELAPID, LIZARD AND SCORPION VENOMS

Carbohydrates exist in venoms in the form of glycoproteins and as free sugars. Aragon et al. (1977) reported that venom from the Central American *Bothrops asper* is very rich in both glycoproteins and free sugars. Glycoproteins are reported in a wide variety of snake venoms (Oshima and Iwanaga, 1969; Basu et al., 1970; Hatton, 1973; Ruff et al., 1980; Marlas, 1982). Viperid and crotalid venoms often contain relatively large amounts of bound carbohydrates when compared with venoms of elapids. These carbohydrates include neutral sugars, amino sugars, and sialic acid (Oshima and Iwanaga, 1967). In this paper we quantitatively compare L-fucose, D-galactose, D-glucose, and D-mannose neutral sugars of whole venoms from snakes, lizards, and scorpions. The venoms were also analyzed for the presence of D-arabinose and D-xylose.

L-fucose and lyophilized venoms of *Agkistrodon bilineatus, Heloderma horridum, H. suspectum, Androctonus australis,* and *Naja naja atra* were purchased from Sigma Chemical Company. The other venoms, also lyophilized, were a gift from Dr. H. L. Stahnke of the Poisonous Animals Research Laboratory at Arizona State University. The other carbohydrate standards were purchased from Chem Service, Inc.; 1-dimethylamino-2-propanol from Aldrich Chemical Company; methanol from MCB Manufacturing Chemists, Inc.; and pyridine from Fisher Scientific Company. All liquid reagents were redistilled prior to use.

Gas chromatography was performed using a Perkin-Elmer Model 3920B instrument equipped with dual flame ionization detectors and 6-ft., 1/8-in.-o.d. nickel columns packed with 1% stabilized diethylene glycol adipate on 100-200 mesh Chromosorb W (HP) by the procedure described by Mawhinney et al. (1980). Data were collected, stored, and analyzed by a Varian Vista 401 Chromatography Data System.

Neutral sugars were obtained by heating 2 to 4 mg samples of venom with 1.0 ml of 0.6 N HCl per mg of venom at 100° for 4 h and eluting in sequence through 0.8 x 8-cm columns of Dowex 1-4X (CO_3^{2-} form, 50-100 mesh) and Dowex 50-8X (H^+ form, 200-400 mesh) with distilled H_2O. One ml of internal standard solution containing 0.0186 mg of phenyl β-D-glucopyranoside was added to the effluent before the sample was concentrated by lyophilization. To convert neutral sugars to oximes, the effluent was mixed with 0.2 ml of a solution containing 0.6 g of hydroxylamine hydrochloride, 2.0 ml of methanol, 5.47 ml of pyridine, and 0.53 ml of 1-dimethylamino-2-propanol and heated at 70° for 5 min in a Teflon-capped Reacti-vial. After cooling to room temperature, a stream of dry air was directed into the open vial to remove excess reagent. Acetate derivatives were prepared by adding 1.0 ml of pyridine-acetic anhydride (1:3 v/v), mixing, and heating the vial at 70° for 25 min. The vial was cooled to room temperature, after which the solution was reduced to a syrup using a stream of dry air. To remove salts, the contents were dissolved in 1.0 ml of chloroform and washed once with 1.0 ml of 1.0 N HCl and three times with 1.0 ml each of distilled water. The chloroform was evaporated with a stream of dry air (Mawhinney et al., 1980). For conversion to aldononitrile acetate (Varmer, et al., 1973), 0.6 ml of pyridine and 1.8 ml of acetic anhydride were added and the mixture was heated at 90° for 30 min. The solution was evaporated to dryness at 40° under diminished pressure with a stream of nitrogen directed into the vessel.

Neutral sugars are present in pit viper, elapid, lizard, and scorpion venoms (Table). D-arabinose and D-xylose were not detected in venoms of *Crotalus molossus, C. scutulatus,* and *N. naja.* Only trace amounts, less than 1 μg per mg of venom, of these sugars were indicated in the other venom analyses. Venom of *A. piscivorus piscivorus* was relatively low in D-mannose. Otherwise, pit viper venoms contained abundant D-mannose, comparable amounts of L-fucose and D-galactose, and relatively small amounts of D-glucose. *A. bilineatus* venom was highest in all the sugars assayed, except D-glucose. D-mannose was not the major sugar in the elapid venom tested; however, D-mannose was dominant in the lizard venom. *Centruroides sculpturatus* venom was higher in total neutral sugar than the other scorpion venoms.

A significant unidentified peak (Fig.), probably indicating another neutral sugar, was recorded immediately prior to the D-mannose peak in the chromatograms of *A. p. piscivorus, C. arrox, N. naja,* and *N. n. atra* venom samples. This peak was minor or absent in the remaining chromatograms. Small unidentified peaks were also recorded immediately prior to the L-fucose peak.

Sialic acid and amino sugar analyses of the above venoms are now in progress.

Table. Neutral Sugars in Various Venoms*+

Venom	L-fuc	D-gal	D-glu	D-man
Pit Vipers:				
Agkistrodon bilineatus	13.3	9.8	1.2	15.4
Agkistrodon contortrix contortrix	1.8	1.6	trace	8.6
Agkistrodon piscivorus piscivorus	3.5	1.2	1.3	1.0
Crotalus atrox	3.0	2.7	1.9	5.6
Crotalus molossus	2.0	2.1	trace	3.0
Crotalus scutulatus	2.5	6.0	trace	8.3
Crotalus viridis cerberus	2.2	4.8	1.5	6.0
Elapid:				
Naja naja	1.1	1.7	1.3	2.5
Naja naja atra	3.2	5.2	1.6	3.2
Lizards:				
Heloderma horridum	2.3	6.3	2.6	7.2
Heloderma suspectum	2.0	4.5	trace	5.1
Scorpions:				
Androctonus australis	1.3	1.0	2.4	1.4
Centruroides sculpturatus	5.9	6.2	4.6	4.6
Hadrurus arizonensis	1.8	1.4	1.3	3.6
Hadrurus hirsutus	1.4	4.4	1.4	4.0

* μg of sugar/mg of venom
+ trace indicates < 1.0 μg of sugar/mg of venom

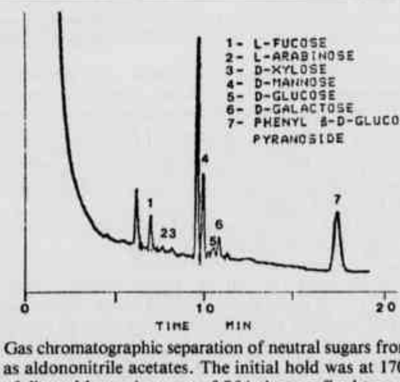

Figure. Gas chromatographic separation of neutral sugars from *C. atrox* venom as aldononitrile acetates. The initial hold was at 170° for two minutes followed by an increase of 8°/min to a final temperature of 240°. Nitrogen flow rate was 24 ml/min and sample size was 4 μl.