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GAS President's Comments and Report from the Academy Council

I would like to thank all those that helped with the recent 2000 Annual Meeting held on the campus of Valdosta State University. The meeting was a great success and we had what I think was a record number of papers presented. I urge all of you to begin and finish those research projects that you have been on the back burner. It will be time for 2001 call for papers before you know it.

The millenium came in with a murmur rather that the bang that had been projected. However all of us need to take note of the things we use, consume and dispose. The ecology of the planet is still in great need of help. Even with the tremendous strides in technology, we are faced with major hurdles in maintaining biodiversity, reversing human population growth, global warming, fossil fuel depletion, etc. It seems a little ironic that the government can spend millions of dollars worrying about the fate of a single child, when only a small portion of that money could have been used to stop the extinction of several unique life forms.

If you have not been to the Georgia Academy home page, http://www.GaAcademy.org, you should visit and stop by frequently for updates. We are still looking for the right individual to become the Georgia Academy of Science's Web Master. If interested, contact me at the address provided elsewhere in the Journal.

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SHORTER COMMUNICATIONS

WIDEBAND PHOTOMETRY OF SATURN: 1999-2000

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ABSTRACT

An SSP-3 solid-state photometer along with a 0.51 m Newtonian telescope and Johnson B, V, R and I filters were used to measure the brightness of Saturn between Sep. 5, 1999 and Jan. 6, 2000. The measured normalized magnitudes of Saturn, extrapolated to a solar phase angle of 0°, are: -8.53±0.02, -9.57±0.03, -10.26±0.02 and -10.46±0.04 in the B, V, R and I filters respectively. The solar phase angle coefficients for Saturn are: $c_B=0.032\pm0.008$, $c_V=-0.035\pm0.011$, $c_R=0.039\pm0.008$ and $c_I=0.034\pm0.017$. The measured V-filter magnitudes of Saturn were, on average, 0.018 magnitudes fainter than the predicted magnitudes in the Astronomical Almanac.

INTRODUCTION

Photoelectric magnitude measurements of Saturn were continued during late 1999 and early 2000. The purpose of this work is to monitor the brightness of Saturn at a ring tilt angle of 20°. A second objective of this study is to monitor long-term color changes in Saturn such as the change in the I-filter brightness (1) and the blue appearance of Saturn (2, 3, 4) during some oppositions. In this paper, photometric constants of Saturn at a ring tilt angle of B = 20.0° are reported.

METHOD AND MATERIALS

An SSP-3 solid-state photometer along with filters that have been transformed to the Johnson B, V, R and I system were used in this study; more information on this instrument can be found elsewhere (5, 6). A 0.51 m Newtonian telescope that was stopped down to 0.05 m was also used. The telescope aperture was reduced to prevent saturation of the photometer detector. The comparison star used for all 1999 measurements was Omicron-Tau, whereas Alpha-Ari was the comparison star for the Jan. 6, 2000 measurements. The check star for the 1999 measurements was Alpha-Ari. The magnitudes for Omicron-Tau were taken from (7) while those for Alpha-Ari were taken from (8) since this is a standard star in that source. The right ascension and declination for both stars along with Saturn were taken from (8, 9). The average measured magnitudes of Alpha-Ari were: B = 3.17, V = 2.02, R = 1.15 and I = 0.59 which are generally close to literature values of: B = 3.15, V = 2.00, R = 1.16 and I = 0.54 (8).

Magnitude measurements in each filter were generally made in the order: CSCSCSKC where C is three 10-second comparison star measurements, S is three 10-second Saturn measurements and K is three 10-second check star measurements. Each magnitude value listed in Table I is an average of three measurements and correspond to one CSCSCSKC series. A typical CSCSCSKC cycle lasted about 30 minutes and so the times are reported to the nearest 0.01 day.

Table I. Photoelectric Magnitude Measurements of Saturn and Other Relevant Data Collected During the 1999 Opposition of Saturn.

		Magnitude		Air Mass			
Date (U.T.)	Filter	Measured	$X(1,\alpha)$[a]	Saturn	Comp. Star	α(°)	B(°)
Sep. 5.34, 1999	B	1.15	-8.35	1.17	1.28	5.7	21.0
Sep. 5.36	V	0.13	-9.37	1.10	1.19	5.7	21.0
Sep. 25.25	B	1.08	-8.36	1.11	1.20	4.4	20.8
Sep. 25.28	V	0.06	-9.38	1.07	1.11	4.4	20.8
Sep. 25.30	R	-0.63	-10.07	1.28	1.45	4.4	20.8
Sep. 25.33	I	-0.84	-10.28	1.18	1.30	4.4	20.8
Oct. 23.17	B	0.94	-8.45	1.26	1.45	1.7	20.3
Oct. 23.19	V	-0.09	-9.48	1.19	1.33	1.7	20.3
Oct. 23.14	R	-0.79	-10.18	1.50	1.85	1.7	20.3
Oct. 23.16	I	-0.97	-10.36	1.37	1.62	1.7	20.3
Nov. 4.16	B	0.85	-8.54	1.19	1.35	0.4	20.0
Nov. 4.18	V	-0.20	-9.59	1.12	1.24	0.4	20.0
Nov. 4.20	R	-0.87	-10.26	1.08	1.15	0.4	20.0
Nov. 4.23	I	-1.10	-10.49	1.07	1.12	0.4	20.0
Jan. 6.17, 2000	B	1.18	-8.37	1.40	1.41	5.6	19.1
Jan. 6.19	V	0.14	-9.40	1.54	1.56	5.6	19.1
Jan. 6.20	R	-0.52	-10.06	1.73	1.77	5.6	19.1
Jan. 6.22	I	-0.76	-10.31	2.00	2.04	5.6	19.1

[a] Computed for a ring tilt angle of B = 20°; see text for details.

All magnitude measurements were corrected for both transformation and atmospheric extinction. Transformation coefficients were measured in the say way as in (1). A value of B=V = 1.02 was assumed for Saturn in all transformation corrections and there was no need to modify this since the value of B-V for Saturn remained within 0.05 magnitudes of 1.02. Extinction coefficients for all dates were measured and applied to the data. Values of k_B “ = -0.03 and k_V” = k_R“ = k_I “ = 0 were also used as in (1). Magnitudes were computed using the procedure outlined in Hall and Genet (10).

RESULTS

The magnitude measurements of Saturn along with relevant parameters are listed in Table I. The first column lists the date of the measurement in universal time, the second column lists the filter, the third and fourth columns list the measured and normalized magnitudes. The fifth and sixth columns list the average air mass that the Saturn and comparison star measurements were made through. The altitude of Saturn and the comparison star at the time of measurement can be computed from:

$$\text{Altitude} = \text{inv sin}\,[1/\text{Air mass value}] \quad (1)$$

The seventh column lists the solar phase angle of Saturn at the time of measurement; the solar phase angle of Saturn is the angle between the Earth and Sun measured from Saturn. The last column in Table I lists the ring tilt angle of Saturn relative to the Earth (8, 9).

The normalized magnitudes of Saturn at a ring tilt angle of 20° were calculated from:

$$X(1,\alpha) = X - 5\log[r\,d] + 2.60\sin[B] - 1.25\mathrm{Sin}^2[B] - 0.743 + 2.5\log[k] \quad (2)$$

where X is the measured magnitude, B is the ring tilt angle relative to the Earth, k is the fraction of Saturn's disc that is illuminated and r and d are the respective Saturn-Earth and Saturn-Sun distances in astronomical units. (One astronomical unit equals the average distance between the Earth and Sun.) The 0.743 term is Δm for B = 20° where $\Delta m = 2.60\sin[20°] - 1.25\sin^2[20°]$ (11). The 2.5log [k] term is always less than 0.004 magnitudes for Saturn, but it was included in this study.

The $X(1,\alpha)$ values were plotted versus α as in (1) and the resulting normalized magnitudes, and solar phase angle coefficients are listed in Table II. The uncertainties in Table II were calculated in the same way as is described in (12).

Table II. Normalized Magnitudes, X(1,0), and Solar Phase Angle Coefficients of Saturn, c_X, Measured During the 1999 Opposition.

Filter	X(1,0) at B = 20°	c_X at B = 20°
B	-8.53±0.02	0.032±0.008
V	-9.57±0.03	0.035±0.011
R	-10.26±0.02	0.039±0.008
I	-10.46±0.04	0.034±0.017

DISCUSSION

The X(1,0) values of Saturn have steadily increased since 1995. Saturn was 0.73 magnitudes brighter in 1999 compared to 1995 due to the increase in the ring tilt. The measured V-filter magnitudes of Saturn were, on average, 0.018 magnitudes fainter than the values listed in the Astronomical Almanac. This suggests that at B = 20° the photometric model in the Astronomical Almanac (8, 9) is accurate. The R-I value in 1999 was 0.20±0.04 which is similar to the value in 1998, 0.25±0.03, but was much higher than the value in 1996, 0.10±0.04, and 1995, -0.02±0.05.

The solar phase angle coefficients of Saturn did not change much between 1998 and 1999 except in the B-filter. The value of c_V = 0.035±0.011 measured in 1999 is a little lower than the value of 0.044 suggested by Harris (11).

The brightness and color of Saturn depend on three factors: 1) orientation of the disc and rings, 2) solar phase angle, and 3) haze and cloud conditions in Saturn's upper atmosphere. Between 1995 and 2002 Saturn will have undergone all ring tilt angles between 0° and 27° and after this has occurred, Schmude will construct a brightness and color model of Saturn. It is hoped that after this model is constructed that future brightness and color studies will yield information on Saturn's haze concentration and cloud structure.

ACKNOWLEDGMENTS

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LONGER COMMUNICATIONS

LEAD SHOT DEPOSITION IN WATERFOWL IMPOUNDMENTS BY COMMON SNIPE HUNTERS

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ABSTRACT

Non-toxic shot restrictions were removed to allow small game hunters to use lead shot for common snipe (Capella gallinago) in drawndown waterfowl impoundments in Butler Island, Altamaha Waterfowl Management Area, Georgia, after the 1992-93 and 1993-94 waterfowl hunting seasons closed. Gizzards collected from waterfowl harvested 2 years prior to (N = 503) and after (N = 236) the regulation changed showed no significant increase in the number of shot ingested following removal of shot restrictions (P = 0.985). Soil samples collected before (N = 120) and after (N = 120) experimental snipe seasons indicated no difference in the number of lead shot present (P = 0.058). The quantity and timing of lead shot deposited by snipe hunters following winter drawdowns had little or no impact on lead shot availability or ingestion by waterfowl using this area the following fall.

Keywords: waterfowl, lead shot, non-toxic shot, impoundments, common snipe.

INTRODUCTION

Lead poisoning associated with ingestion of lead shot used for waterfowl hunting is well documented (1, 2, 3, 4, 5). Researchers (1, 3, 6) have suggested the supply of lead shot available to foraging waterfowl is largely due to current year's deposition. Lead shot restrictions for waterfowl hunting were mandated nationwide by the U.S. Fish and Wildlife Service with the 1991-92 hunting season to alleviate lead poisoning problems associated with waterfowl hunting activities.

The use of non-toxic shot for waterfowl hunting on the Altamaha Waterfowl Management Area (AWMA) was mandated in 1986. Sportsmen hunting small game besides waterfowl inside waterfowl impoundments were allowed to use lead until the 1990-91 hunting season, when all hunters were required to use non-toxic shot for all species hunted. During the 1992-93 and 1993-94 hunting seasons, small game hunters pursuing common snipe were allowed to use lead shot after the waterfowl season. To date, occurrences of lead poisoning in waterfowl or other species have never been documented in this area.

The primary species hunted on the AWMA are ducks; however, common snipe also are heavily hunted after waterfowl season when snipe concentrate on drawndown impoundments. Effects of lead deposition from snipe hunting following waterfowl dispersals and its contribution to lead toxicity problems for waterfowl the following fall are unknown. Little information exists concerning the deposition of toxic shot on waterfowl impoundments after the impoundments have been drained and ducks are no longer present. We explored the effects of snipe hunters using lead shot on moist waterfowl impoundments after waterfowl season.

MATERIALS AND METHODS

This study was conducted on Butler Island, one of many islands associated with the AWMA, located in McIntosh County, Georgia. The 10,958 ha AWMA borders the Altamaha River and is managed by the Georgia Department of Natural Resources to provide quality habitat for wintering waterfowl and other wildlife. Soils on the area are alluvial in nature, very poorly drained, and highly acidic. Soil texture is largely clay but often contains a high organic content. Infiltration and permeability are retarded because of the relatively high water table throughout much of the year. Average annual precipitation is 130 cm. Topographic relief is limited to a 2% slope inside diked impoundments.

Management activities on AWMA include water level manipulation, periodic mowing, herbiciding, burning, and disking to control noxious vegetation and improve available waterfowl habitat. Water levels are manipulated on 1,295 ha of converted rice fields to encourage growth of native waterfowl foods through the 276 day growing season. Target species included smartweeds (Polygonum spp.), wild millets (Echinochloa spp.), pancium (Panicum spp.), flat sedges (Cyperus spp.), wigeon grass (Ruppia maritima), bulrush (Scirpus spp.), and spikerush (Eleocharis spp.).

Impoundments on the AWMA typically are flooded in November and remain inundated until the end of the waterfowl season, usually late January. Water depths within impoundments average 25-35 cm during the winter but vary throughout the growing season depending on desired management objectives and existing habitat conditions. Butler Island consists of 6 freshwater impoundments totaling 410 ha.

A total of 21 days and 80 days of opportunity were afforded waterfowl and snipe hunters, respectively, during this study, which included 4 hunting seasons, 1991-1995. Waterfowl hunts on the Butler Island Unit were conducted on Saturday mornings during statewide waterfowl hunting seasons. Hunters were selected on a lottery basis and randomly assigned to 30 available blind areas averaging 10 ha in size. Participants were required to abide by all applicable state and federal waterfowl hunting regulations including shot restrictions, bag limits and season dates. Hunter effort and harvest were recorded for all participants.

During waterfowl season, snipe were hunted on the Butler Island Unit during managed duck hunts on Saturdays. After waterfowl season, snipe were hunted on Wednesdays, Saturdays and Sundays through the end of February.

Gizzards were collected from waterfowl harvested on Butler Island during the 1991-1995 seasons and examined for shot ingestion. Gizzards collected during the 1991-1992 and 1992-1993 waterfowl hunting seasons were considered pre-treatment, and gizzards collected during the 1993-1994 and 1994-1995 waterfowl hunting seasons were considered post-treatment because shot restrictions for snipe hunting were removed in January 1993 after waterfowl hunting season had closed. During managed hunts, area personnel obtained gizzards voluntarily from hunters. The gizzards were labeled and immediately frozen.

Later, gizzards were thawed and examined for external and internal wounds to identify any shot that was not ingested, but was present as a result of a gunshot wound. Gizzards were sectioned longitudinally and the contents were washed through a series of fine mesh screens that would not allow a number 8 lead shot to pass through. Running water was used to minimize sample volume. Contents that did not pass through the sieve were washed into a white enamel pan and examined for the presence of shot. All metals were tested on a magnet to separate lead from other metals such as non-toxic shot, and metals that could be identified as shot were recorded.

Gizzard examination data were analyzed using a one-tailed student's $\underline{t}$-test (7). We tested the null hypothesis that the proportion of gizzards containing lead shot does not increase following the removal of shot restrictions against the alternative that the proportion of gizzards containing lead shot does increase following the removal of shot restrictions.

Soil samples were collected from inside managed waterfowl impoundments on Butler Island. A sample of 3 blind sites was randomly selected from an available 30 sites. Twenty soil samples were collected randomly from inside each blind area during all sampling dates totaling 240 samples. Soil samples were collected 4 times between 1993 and 1994 representing 2 pre- (Jan and Nov 1993) and 2 post-snipe season (March 1993, 1994) sampling periods when lead shot was legal. Each sample consisted of a core of soil collected with a 9.84-cm diameter soil auger pushed to a target depth of 10.16 cm. All samples were placed in individual plastic bags, labeled and stored for later evaluations.

Soil samples were washed through a series of fine mesh screens that would not allow a number 8 lead shot to pass through. Running water was used to remove soil particles and minimize sample volume. Contents that did not pass through the sieve were washed into a white enamel pan and examined for the presence of shot. All metals were tested on a magnet to separate lead from other metals, and metals that could be identified as shot were recorded.

Soil survey data were analyzed as a two-way analysis of variance with replication (7). Season of sampling (before vs. after snipe season) and blind area (A, B, or C) served as factor variables. The study was replicated for two years (1992-93 and 1993-94 hunting seasons). A test for interaction between season and blind area yielded no significant interaction ($P = 0.870$) for lead or for steel ($P = 0.630$). As such, F values and P values were recalculated for blind effects and season effects after pooling the mean square for interaction with the mean square for error (7). For all tests, alpha = 0.05 level of significance was used.

RESULTS

During the 1991-1995 hunting seasons, 1,225 waterfowl hunters harvested 1,302 ducks on Butler Island, averaging 1.06 ducks/person/day. In addition, 18 common snipe, 45 American coots (Fulica americana), and 28 hooded mergansers (Lophodytes cucullatus) were harvested during the 21 managed duck hunts.

Only 5.95% of gizzards from 739 ducks representing 11 species contained spend shot (Table I). There were 4 species of ducks with ingested lead shot compared to 7 species with ingested steel shot (Table II). Of the 44 shot recovered, 13 were lead, and 31 were steel. The size of lead shot recovered was consistent with number 6-8 shot used primarily for snipe hunting. No gizzard contained more than one shot. There was no significant increase in the proportion of gizzards containing lead shot following removal of restrictions (P = 0.985). There was no difference in the occurrence of steel shot (P = 0.217).

Table I. Shot occurrences in duck gizzards from Butler Island, Altamaha Waterfowl Management Area, Georgia, 1991-1995.

Shot Allowed for Snipe	N	Lead Shot No. w/Shot	Lead Shot %	Steel Shot No. W/Shot	Steel Shot %
Steel (1991-93)	503	12	2.39A[a]	24	4.77A
Lead (1993-95)	236	1	0.42B	7	2.97A
Total	739	13	1.76	31	4.19

[a] Within columns, values with the same letter were not significantly different ($\underline{P} > 0.05$)

Table II. Shot ingested by species on Butler Island, Altamaha Waterfowl Management Area, Georgia, 1991-95 hunting seasons.

		Lead Shot		Steel Shot	
Species	N	No. w/Shot	%	No. W/Shot	%
Wood Duck	320	2	0.7	4	1.3
Green-Winged Teal	232	1	0.4	3	1.3
Blue-Winged Teal	68	0	0.0	2	2.9
Ring-Necked Duck	41	9	22.0	17	41.5
American Wigeon	39	0	0.0	1	2.6
Mallard	22	1	4.6	3	13.6
Northern Pintail	8	0	0.0	1	12.5
Northern Shoveler	5	0	0.0	0	0.0
Lesser Scaup	2	0	0.0	0	0.0
American Black Duck	1	0	0.0	0	0.0
Gadwall	1	0	0.0	0	0.0
Total	739	13	1.8	31	4.2

A survey of 240 soil samples yielded 17 pellets, 15 lead and 2 steel (Table III). The total area sampled was 1.83 m^2. There was no significant difference in the number of lead pellets recovered after snipe season than before ($P = 0.058$). The number of lead shot recovered did vary significantly among blind areas ($P = 0.048$). For steel shot, there was no significant difference in the amount of shot found by season ($P = 0.169$) or blind area ($P = 0.586$).

Table III. Soil samples containing spent shot collected on Butler Island, Altamaha Waterfowl Management Area, Georgia, 1993-94.

		No. w/Lead[a]		No. w/Steel[b]	
Blind	N	Before	After	Before	After
A	40	0	2	1	0
B	40	3	5	1	0
C	40	2	3	0	0
Total	120	5	10	2	0

[a] The number of lead pellets varied significantly by blind ($\underline{P} = 0.048$), but did not vary significantly by season ($\underline{P} = 0.058$).

[b] The number of steel pellets did not vary significantly by blind ($\underline{P} = 0.586$) or by season ($\underline{P} = 0.169$).

DISCUSSION

Of the gizzards containing lead shot, only 1 was collected in the 2-year period after lead shot was legalized for snipe hunting. Nearly all of the lead shot (92.31%) was recovered from gizzards collected during a period when the use of lead shot had been banned totally. This suggests factors other than the current year's deposition greatly affected shot occurrence in gizzards. Waterfowl harvested on Butler Island during this study may have obtained lead during foraging efforts prior to arrival on this area. Although no significant annual deviations in management practices occurred during this study, certain activities such as disking may expose shot to foraging waterfowl.

Despite representing only 5.82% of gizzards surveyed, gizzards from diving ducks contained 59.09% of ingested shot. The relatively high ingestion rate expressed by diving ducks is consistent with other reports (1). Management efforts on the AWMA are designed primarily to attract puddle ducks rather than diving ducks.

There are two possible reasons why the number of lead shot present in the soil samples was not significantly higher after snipe season. Either snipe hunters were not depositing enough lead shot to make a difference, or the lead shot was rapidly sinking in the soft mud bottom of the impoundments.

Soil characteristics contribute greatly to the availability of spent shot to foraging waterfowl (1, 3). In areas where soft mud bottoms are prevalent, pellets sink faster and become unavailable to foraging waterfowl quicker than in areas where hard, shallow bottoms prevail (1). Bellrose (2) and White and Stendell (6) showed the depth to which spent shot sink was partially a function of the time spent on the area. Since 8 months lapsed between snipe hunting and use by wintering waterfowl, many shot apparently sank deeper than normal foraging lengths. Likewise, lead shot deposited from snipe hunters and from previous years of waterfowl hunting may have sank below soil sampling depths used in this study.

Lead shot collected did not appear to have deteriorated significantly, although some steel pellets displayed varying degrees of deterioration and may have been under-represented. Manual examination of gizzards also is known to underestimate ingestion of shot by 20-25% (8). Difficulty in detecting eroded shot among other gizzard contents was the main factor influencing error in examination (9).

Bellrose (1) suggested the number of lead shot ingested was closely associated with waterfowl mortality, and ducks ingesting only a single pellet had an increased chance of survival compared to ducks that ingest 2 or more pellets. The absence of gizzards containing multiple pellets in this study was encouraging since Bellrose (1) stated that "lead poisoning at the one shot level does not constitute a truly depressive influence on waterfowl."

Number of recovered pellets was variable among blind areas. Hunting pressure, and therefore shot distribution, varied from area to area and year to year and accounted for much of the variability in shot deposition. Amount and distribution of spent shot are likely also a function of game concentrations, accessibility, water levels and vegetative cover.

The timing and quantity of lead deposited by snipe hunters had little or no impact on the ingestion rate for sympatric waterfowl on the AWMA. Many unique factors including intensity of hunting, type of soil, depth and periodicity of inundations, and waterfowl use contributed to these findings. A continued relaxation of non-toxic shot regulations for snipe hunters following winter drawdowns is recommended on this area provided current management activities and levels of hunting pressure remain stable. Moist impoundments receiving lead dosages from small game hunters should not be flooded during the growing season to temporarily discourage migratory and resident duck use. Areas with hard, shallow bottoms, greater hunting pressure, and greater waterfowl use may require a more restrictive approach to non-toxic shot regulations.

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NOTES ON THE BIOLOGY OF DYTISCUS CAROLINUS AUBÉ (COLEOPTERA: DYTISCIDAE) IN CENTRAL GEORGIA WITH A DESCRIPTION OF ITS MATURE LARVA

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ABSTRACT

Larvae of Dytiscus carolinus Aubé were collected between mid-February and early April from an oligoxeric marsh and cultured to the adult stage. The occurrence of larvae suggests that oviposition occurred in January or early February in this Fall Line habitat and that adults could have emerged at the site as early as April. Analysis of the mature larva revealed structures that corresponded generally to that expected for Dytiscus, including secondary (pseudo-) segmentation of the proximal labial palp.

Key words: Coleoptera, Dytiscidae, Dytiscus carolinus, larva, morphology, reproduction, Georgia Fall Line.

INTRODUCTION

The Holarctic genus Dytiscus includes 26 species, with representatives occurring from the Arctic and subarctic southward to the Himalayas, North Africa, and Central America (1). However, in the Nearctic region, species richness is greater in cold temperate environments with few species having ranges that extend into the southeast (2). Representatives of the genus were not reported from the Deep South until 1954 when Young (3) discovered a population of Dytiscus in the Coastal Plain of southwestern Georgia. Subsequently, Young's specimens were identified as Dytiscus carolinus Aubé (1) with records of this taxon now known from most of the southeastern states, excluding Florida (4). Its range extends northward along the Mississippi River into Wisconsin and along the Atlantic Coast into New England (1). Both Epler (4) and Roughley (1) indicated that Dytiscus carolinus (D. fasciventris Say) is the only species reported south of the Carolinas. However, Turnbow and Smith (5) included D. verticalis Say in the Georgia fauna, and other species have been reported (1) for Tennessee (D. cordieri Aubé) and South Carolina (D. hybridus Aubé), making it possible that these also occur in Georgia.

Korschelt's (6) comprehensive study of the European species Dytiscus marginalis Linnaeus, perhaps the most detailed study available for any species of dytiscid, contains descriptive information for the egg and larval stages. Nilsson (7) included representatives of Dytiscus in his assessment of primary setae and pores on legs of larval Dytiscidae; however, this study was also based on European material. In the Nearctic region, Kincaid (8) provided limited descriptive information for D. dauricus Gebler. More detailed descriptions are available for immatures of D. verticalis (9) and D. fasdiventris Say (10). Additional, but brief, descriptive information is available for larvae of D. dauricus Gebler, D. cordieri Aubé (as D. sublimbatus LeConte), D. fasciventris, (11) and D. hybridus Aubé (12). Aiken and Wilkinson (13) described the immature stages of D. alaskanus J. Balfour-Browne and provided an evaluation of its cycle strategy and phenology. Hilsenhoff (14) also gave some general information on the natural history of D. carolinus and seven other species of Dytiscus that occur in Wisconsin.

We are not aware of any descriptive and life cycle information for Dytiscus carolinus. The objectives of this study are to provide a description of the mature larva of D. carolinus and an assessment of the life cycle strategy and reproductive habitat requirements of a southeastern poopulation of the species.

MATERIALS AND METHODS

Triangular nets and bottle (bottom) traps (15) were used to collect an oligoxeric (16) marsh habitat located on the Fall Line (17) at the intersection off US Highway 80 and Richland Creek in Talbot Co., Georgia. Larvae were reared to the adult instar in a Kewannee environmental chamber set for a 12 hour photoperiod and 18°C. Larvae were removed from the environmental chamber for daily feeding and cleaning of culture vessels. They were fed bloodworms, tadpoles of various sizes, and newly metamorphed frogs when larvae were near maturity. When larvae ceased feeding and/or became lethargic, water was removed from culture containers and replaced with damp paper towels. Containers were then placed on a layer of damp sand in a covered opaque plastic box and left in the environmental chamber at the above settings for pupation and emergence of adults.

Measurements were of preserved larvae (n = 10) with heads, legs, and usually urogomphi removed. Head length was taken dorsally parallel to the coronal suture from the posterior margin to the anterior margin of the frontoclypeus, excluding clypeal lamellae. Head widths were taken at the widest point, and measurements of other structures were along either the greatest length or width. Nine preserved larvae and one cast skin of a mature larva were chosen for structural description. Commonly employed anatomical terms were used to indicate position of individual sensilla and/or groups of sensilla on segments of the body and appendages. This is a modification of a descriptive approach that was presented by Wolfe and Roughley (18). Variations of this method have been used in a number of studies concerned with the description of dytiscid sensilla (e.g., 7, 19, 20, 21, 22, 23, 24).

RESULTS

Larvae were collected from shallow (≤50 cm) areas where Scripius was the dominant macrophyte. Immature anurans, newts and fish (e.g., Notropis sp.

and Esox sp.) were present. The marsh supported a diverse invertebrate fauna, including large numbers of crayfish, Daphnia, odonate immatures, mayfly larvae, and bloodworms. In addition to Dytiscus carolinus, a number of other dytiscids were using the marsh as a breeding site. Larvae of Neoporus undulatus (Say), Agabus punctatus Melsheimer and unidentified larvae of Agabus, Hydroporus, and Hydaticus were collected occasionally with those of D. carolinus.

First, second, and third instar larvae were taken only with nets, from 11 February until 2 April 1997. Adults of Dytiscus carolinus were not collected in the habitat although adults of Cybister fibriolatus Say were taken in bottle traps. In the laboratory, the duration of the second stadium was 6-8 days while the duration of the third stadium (including the prepupal period) was 15-20 days. The pupal stage lasted 14-15 days.

The larva of Dytiscus carolinus was yellowish brown along the dorsal surface, and lighter brown or tan laterally and ventrally. The general form was elongate and spindle-shaped, tapering both anteriorly and posteriorly. The mature larva may be identified to genus by its size (preserved length, excluding urogomphi, ca. 40 mm) and a combination of characters that include a broadly and smoothly rounded frontoclypeus, abdominal segments 7 and 8 with well-developed lateral fringes of sensilla, and a labium that is smoothly concave anteriorly between the palpi (25).

The head had a mean dorsal length of 5.83 ± 0.25 mm and a mean width of 4.80 ± 0.19 mm with a well-developed cervical area and a distinct occipital suture. A rudimentary dorsal visual organ had a length one and a half times the diameter of the adjoining ocellus. Prominent sensillar series included hair-like sensilla of the ocular region, cervical spines arranged in two rows of three sensilla each on the dorsum posterior to the occipital suture, frontoclypeal lamellae, and small sensilla posterior to but parallel with the anterior margin of the frontoclypeus. No temporal spines were observed and additional dorsal and ventral sensilla were not arranged in well-defined series.

Mandibles were setose along inner edges but exhibited no evidence of serrations. The mean length of the proximal segment of the labial palp was 0.70 ± 0.03 mm and that of the terminal segment 0.39 ± 0.04 mm with both segments exhibiting false or secondary segmentation (Fig. 1). The proximal labial segment bore two short sensilla, and a single hair-like sensillum was observed on the second. A group of sensilla, consisting of one long, hair-like and several shorter spines was present near the origin of each labial palp. Each segment of the maxillary palpi was segmented secondarily and had mean lengths of 0.92 ± 0.07 mm (first segment), 0.93 ± 0.13 mm (second segment), and 0.84 ± 0.14 mm (third segment). The second segment of the maxillary palp had two hair-like sensilla and the terminal segment one hair-like sensillum. The proximal antennal segment (length = 1.92 ± 0.22 mm) was unmodified with the second (length = 1.21 ± 0.06 mm) and third (length = 1.14 ± 0.11 mm) segments psuedosegmented and the terminal segment greatly reduced in length. The proximal antennal segment had a linear series of small sensilla on the interior surface.

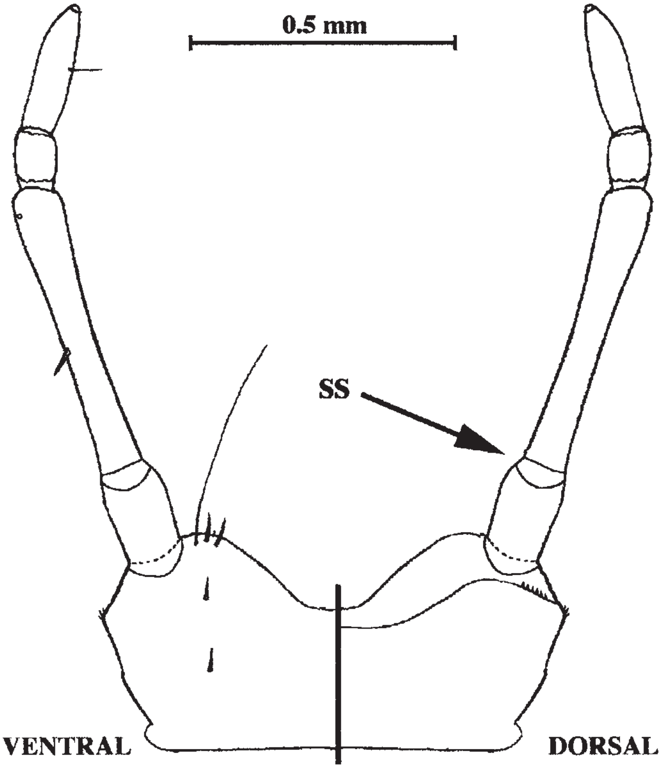

Figure 1. Labium of Dytiscus carolinus Aubé showing secondary (pseudo-) segmentation (SS).

The prothoracic tergite bore a series of hair-like sensilla, originating near the dorsum, extending ventrally to near the anterior margin, and continuing along lateral and posterior margins. A prothoracic sternite was glabrous, prominent, and shield-shaped. Setation of the meso- and metanota consisted of series of posterior and posterolateral hair-like sensilla with few dorsolateral hair-like setae discally. The openings of the thoracic spiracles were near the anterolateral margin of the mesonotal tergite and were surrounded by a flange that protruded slightly above the surface.

Meso- and metathoracic legs were subequal in length and longer than prothoracic legs (Table I). Coxae were without sutures and lacked sensilla on the anteroventral surfaces between the proximal and distal series. Meso- and metacoxal antero- and posterodorsal sensilla were interpreted as having natatory functions. The distal regions (2TR) of trochanters were moderately constricted just beyond the annular line and then distended ventrally (Fig. 2). All trochanters had anteroventral series of natotory sensilla although this series was less developed on the proleg. Natatory sensilla were the dominant setation of femora, tibiae, and tarsi (Table II; Fig. 2) Each trochanter, femur, and tibia bore well-defined series of anteroventral sensilla with those on the femora and tibiae continuous with anteroventral distal sensilla. Inconspicuous series of sensilla (anterior face) were observed between the anteroventral series and the anterodorsal series of femora and tibiae. Robust ventral spinulae (combs) were confined to the distal third of the meso- and metatarsi and the distal half of the protarsus. Anterior tarsal claws were longer than posterior claws on all legs with each bearing a well-developed basal spine.

Table I. Lengths (n=10; in mm) of legs and leg segments of Dytiscus carolinus Aubé.

Leg[1]/Segment	Mean	Standard Deviation	Range
Procoxa	2.84	0.16	2.47-3.06
Mesocoxa	3.25	0.17	2.93-3.58
Metacoxa	3.11	0.12	2.92-3.57
Protrochanter	1.00	0.04	0.98-1.11
Mesotrochanter	1.13	0.06	1.11-1.30
Metatrochanter	1.16	0.07	1.11-1.30
Profemur	2.95	0.18	2.60-3.25
Mesofemur	3.67	0.20	3.32-3.90
Metafemur	3.59	0.25	3.25-3.90
Protibia	2.12	0.11	1.95-2.28
Mesotibia	2.82	0.27	2.15-3.06
Metatibia	3.12	0.23	2.60-3.32
Protarsus	1.39	0.09	1.30-1.50
Mesotarsus	1.78	0.09	1.63-1.89
Metatarsus	1.93	0.09	1.82-2.15
Proleg	9.34	0.33	8.58-9.76
Mesoleg	11.52	0.52	10.66-11.98
Metaleg	11.74	0.52	10.92-12.49

[1] Lengths of legs is the sum of the individual segments, excluding trochanters.

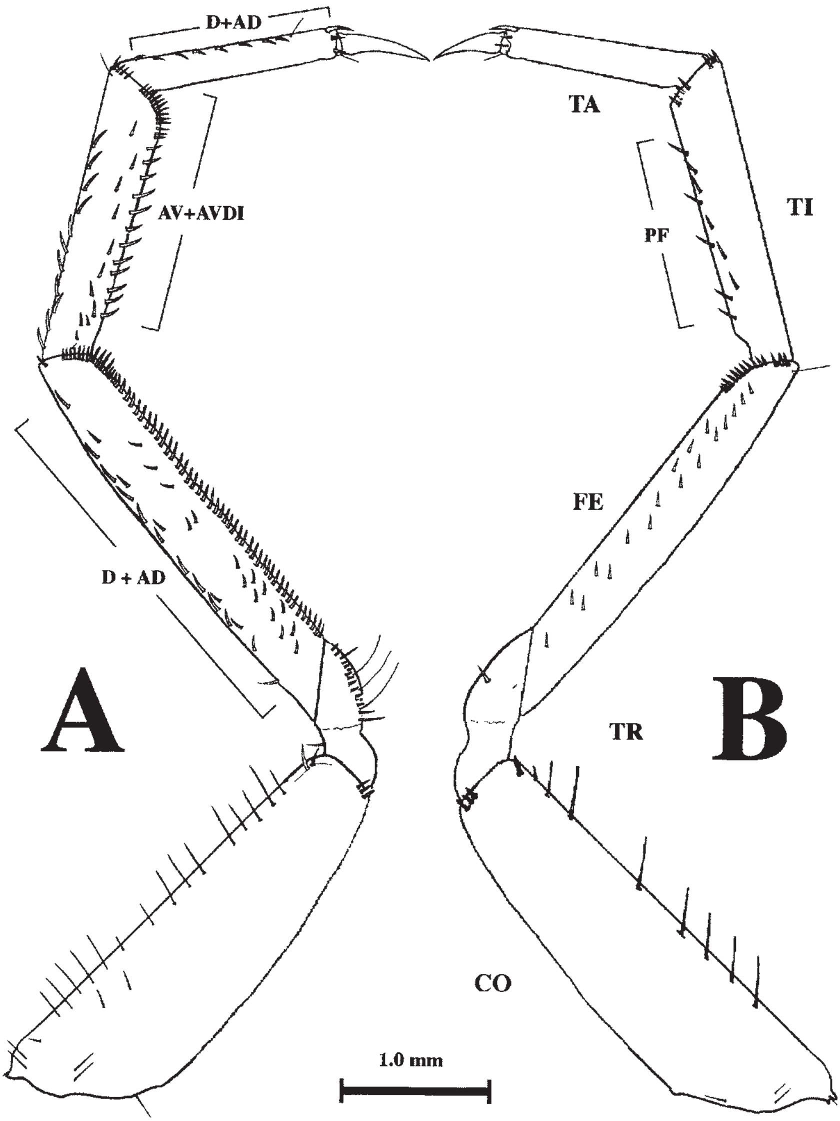

Figure 2. Anterior (A) and posterior (B) views of the prothoracic appendage of Dytiscus carolinus Aubé. Natatory sensilla of the femur, tibia, tarsus are not shown. Abbreviations shown include: D, dorsal; AD, anterodorsal; AV, anteroventral; ADDi, anterodorsal distal; AVDi, anteroventral distal; and PF, posterior face.

Table II. Sensillar patterns on legs of the mature larva (n=10) of Dytiscus carolinus Aubé.

Appendage	Location[1]	Coxa	Femur	Tibia	Tarsus
Proleg	D+AD	9-19	12-20	6-14	6-9+1 hrl
	AF	-	12-21	6-17	-
	AV + AVDi	-	34-56	23-41	-
	ADDi	2	1-2	2-7+1 hrl	1
	AVDi	1-3	-	-	1
	APr	6	-	-	-
	PD	9-13	0	0	0
	PF	-	14-24	5-13	0
	PDDi	1-2	0-3+1 hrl	2-4	1
	PVDi	1-4	8-15	4-7	1
	PPr	4	-	-	-
Mesoleg	D+AD	NA	14-21	13-21	8-10+1 hrl
	AF	-	16-24	6-18	-
	AV + AVDi	-	31-62	17-37	-
	ADDi	2	1-2	2-5+1 hrl	1
	AVDi	3-4	-	-	1
	APr	6	-	-	-
	PD	7-12	0	0	0
	PF	0-1	15-26	10-15	0
	PDDi	2	0-2+1 hrl	2-5	1
	PVDi	3-5	6-12	5-11	1
	PPr	4	-	-	-
Metaleg	D+AD	NA	17-22	12-23	8-10+1 hrl
	AF	-	14-27	7-14	-
	AV + AVDi	-	42-57	15-35	-
	ADDi	2	0-1	3-5+1 hrl	1
	AVDi	2-4	-	-	1
	APr	6	-	-	-
	PD	5-8	0	0	0
	PF	-	13-22	8-17	0
	PDDi	1-3	1+1 hrl	2-4	1
	PVDi	3-9	6-11	5-12	1
	PPr	4	-	-	-

[1] Abbreviations employed include: D, dorsal; AD, anterodorsal; AF, anterior face; AV, anteroventral; AVDi, anteroventral distal; ADDi, anterodorsal distal; APr, anteroproximal; PD, posterodorsal; PF, posterior face; PDDi, posterodorsal distal; PVDi, posteroventral distal; PPr, posterior proximal; and hrl, hair-like.

Abdominal segments 1 through 6 were sclerotized dorsally only, and segment 7 was sclerotized dorsally and laterally. A well-defined series of abdominal swimming hairs were observed laterally on segments seven and eight. A weaker horizontal array of hair-like sensilla was observed on the pleural regions of the remaining abdominal segments, with sensilla increasing in number from segments 1 to 6. The mean length of segment 8 was 4.95 mm ± 0.17 mm with a short siphon and single segmented urogomphi (length = 0.79 ± 0.07 mm). Segment 8 was completely sclerotized with the ventral surface containing numerous small spines except ventrodistally. Each urogomphus bore a small sensillum proximally and numerous, long, hair-like sensilla, arising laterally to produce a plumose appearance.

DISCUSSION

Aiken and Wilkinson (13) found that, in Alberta, adults of Dytiscus alaskanus overwinter to oviposit in mid- to late April with first instar larvae appearing in mid- to late May and third instar larvae observed in August. Hilsenhoff (14) stated that adults of Dytiscus mate very early in the spring and oviposit when their breeding habitats become free of ice in late March to early May. Hilsenhoff (14) and Aiken and Wilkinson (13) concluded that species of Dytiscus have univoltine life cycles. First, second, and third instar larvae of D. carolinus were collected in this study in mid-February suggesting that oviposition occurred in January or early February and that adults could have emerged at this site as early as April. Because D. carolinus was found in Georgia much earlier in the year than species of Dytiscus in either Alberta or Wisconsin, it is possible that it is either bivoltine or multivoltine in Georgia.

Larval morphology of Dytiscus carolinus is similar to that shown for D. fasciventris by James (10). Possible differences include the presence of 2 hair-like sensilla on the proximal labial palp of D. carolinus that are not shown for D. fasciventris. In addition, the dorsal visual organ of D. fasciventris is illustrated showing a diameter that equals the length of nearby ocelli, while this structure on D. carolinus has a diameter that was ca. 1.5 x the length of the nearest occellus. The dorsal visual organ was also contiguous with the nearest ocellus, but is shown on D. fasciventris as separated by a narrow isthmus from the nearest ocellus. Basal morphology of the labial palp shown by James (10) is very similar to that observed for D. carolinus. In illustrating the mature larva of D. verticalis, Wilson (9) showed this species without corresponding basal secondary segmentation on the proximal labial palp. Although Roughley (1) appears to confirm Wilson's observation, Wilson's description is suspect.

It was suggested earlier (26) that a diagnostic character for separating larvae of Dytiscus carolinus and D. verticalis was the presence (D. carolinus) or absence (D. verticalis) of secondary segmentation of the proximal labial segment. However, two additional species, D. cordieri and D. hybridus may occur in Georgia. Given that the proximal labial segments of D. hybridus, and possibly that of D. cordieri (1), is also segmented, it is apparent that additional descriptive and biogeographical information is required before reliable keys can be developed that differentiate mature Dytiscus larvae of Georgia.

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LEAD IN PAINT IN WEST GEORGIA: X-RAY DIFFRACTION, ICP AND HACH COLORIMETER ANALYSIS

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ABSTRACT

The Environmental Protection Agency (EPA) and the Centers for Disease Control and Prevention (CDC) have declared lead, Pb, to be the number two environmental hazard in the United States. Ingestion of lead paints, contaminated dust, and soil is the leading cause of lead poisoning in young children. Therefore, a study was begun in the west Georgia region to determine lead content of paint on public and private buildings, the present crystalline state of lead in paint and to determine the lowest level of lead in paint detectable by X-ray diffraction. One interior and one exterior paint sample was obtained from 15 buildings built between 1843 and 1954 in Carrollton and Rome, Georgia. Thus, the present study is a reconnaissance study using minimum sampling methods. Samples were ground into a powder and analyzed for crystalline phases by X-ray diffraction methods. Weight percent of lead was determined by an EPA developed field-test method using a Hach colorimeter and by ICP analysis. Lead phases detected by X-ray diffraction include synthetic hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), synthetic crocoite ($PbCrO_4$), synthetic phoenicochroite (Pb_2CrO_4O), synthetic anglesite ($PbSO_4$), and possible synthetic plattnerite (PbO_2). Chemical analysis of the paints determined their lead contents range from 0.004 wt.% Pb to 10.8 wt.% Pb. Our results indicate that as the lead paint weathers it hydrates and is transformed from lead oxides and lead carbonates to hydrated lead compounds. Comparing the results from the Hach colorimeter and the X-ray diffraction methods show that the detection level of lead in paint by X-ray methods is between 1.05 and 2.67 wt.% lead.

Key Words: lead paint, public buildings, west Georgia, X-ray diffraction, lead analysis

INTRODUCTION

Lead paint was first introduced because of its high resilience to weathering and deterioration. Lead-based paint's popularity was also due to its ability to last longer, resist mildew and keep brilliant color. Lead paint has been declared an environmental hazard since 1904, when scientists in Queensland, Australia proved lead paint was poisoning children. Lead paint was banned in Southern Australia in 1922. What was ignored for decades in the United States was that toxic lead could contaminate children's bodies through inhalation/ingestion of lead in dust, soils or paint chips. Lead-based paints were banned in the United States in 1977; by this time 200 children per year were dying of lead poisoning (1). The U.S. Department of Housing and Urban Development (HUD) estimates that there are three million tons of lead in 57 million homes built before 1980 (2). Prior to 1997 the CDC and EPA had declared lead poisoning to be the number one environmental hazard (3, 4). Lead is second behind arsenic on the 1999 Comprehensive Environmental Response, Compensation, and Liability List of Priority Hazardous Substances (4). It has been estimated that one million children or 4.4% of children below five years of age have harmful blood levels (i.e., > 10µ/dL blood lead levels) (5). Lead is also found in such items as food containers (6), drinking water from old plumbing (7-9), old insecticides (10), crystal glass (1), metallic batteries (8), and paint on fire hydrants, curb sides and highway markers (11-13).

Lead is detrimental to children because their bodies are developing. When lead is introduced into the body it replaces calcium in the bones and attacks vital organs such as the liver and brain (5, 14-15). Children exposed to high lead levels may experience hazardous side effects such as nausea, seizures, lethargic activity, moderate hearing/memory loss, and behavioral problems (16-17). Lead poisoning can cause liver and brain damage and death (18). Lead has been proven to lower IQ by four to five points (19-21). When the body is contaminated the lead attaches itself to tissues where it will remain. Lead poisoning can also affect common household pets; for example, President Bush's dog Millie showed all the symptoms of lead poisoning from chewing on the White House (22).

Lead (Pb) can be found in several crystalline states within the paint. Examples of these are synthetic cerussite or lead carbonite ($PbCO_3$), synthetic anglesite or lead sulfate ($PbSO_4$) and synthetic crocoite or lead chromate ($PbCrO_4$). Knowing the crystalline state of lead is important because some are more soluble (i.e., Pb-carbonates and Pb-hydrates) in water and stomach acids than others (i.e., Pb-oxides). Determining the crystalline state of lead phases in paints is the first goal of this research project achieved by X-ray diffraction analysis. The second goal is to detect the changes of the crystalline state over a period of time. This goal is necessary to determine if the lead oxides and lead carbonates originally in the paint have been hydrated over the passing decades. The third goal is to determine concentration of lead in paint with a Hach colorimeter. Comparing the results of the two sets of analytical data from the X-ray and colorimeter will provide answers to the lowest level of lead detection in paint by X-ray diffraction. The fourth goal is to check for lead paint in public buildings in the west Georgia region.

Preliminary results were presented by Boyles et al. (23). They determined lead paint is common in old buildings of west Georgia and that X-ray diffraction methods could detect lead phases in paint. Rather than follow the sample protocol outlined in for example the Department of Housing and Urban Development (HUD) (2) that requires 20 samples Boyles et al. (23) did a reconnaissance study that involved one exterior and one interior sample. The exterior sample was collected from the front entrance of each building. Samples were collected from frames around doors and windows and from windowsills. Interior samples were collected from the first floor near the front entrance.

METHODS

To determine which samples contained the lead pigment three analytical procedures were used. The first method was powder X-ray diffraction. Samples were collected with 1 1/4 inch wide paint scrapers from old buildings in the west Georgia region. Being a reconnaissance study one interior and one exterior sample was collected from each building. All samples were ground into a fine powder with an agate mortar and pedestal. Powders were examined with a binocular microscope to ensure uniform grain size. Part of the sample was placed on a 32 mm aluminum sample holder as a smear mount for X-ray diffraction analysis. X-ray analysis was done using a Philips PW 3719 generator with a copper tube ($CuK\alpha$) operated at 40 kv and 40 mA and a PW 3020 diffractometer with spinning stage. Control and identification software was Philips PC-APD and PC-Identify software. A typical scan was from 5 to 63° 2Θ. Machine alignment was assured by running standards of quartz, rutile, muscovite and kaolinite. Standards used were quartz from Coleman's Mine, Hot Springs, Arkansas ((100) at 4.257Å and (101) at 3.342Å), rutile from Graves Mountain, Georgia ((110) at 3.247Å and (211) at 1.6874Å), kaolinite from Sandersville, Georgia ((100) at 7.20Å and (002) at 3.56Å), and muscovite from a Black Hills pegmatite, South Dakota ((002) at 9.98Å). Synthetic quartz (strong peaks on 18 of 21 samples) and rutile (strong peaks on all samples) in the paint samples provided an "internal standard" to ensure correct sample position on the spinning stage. The measured X-ray peak intensities for the paint samples were compared with the known peak intensities of minerals and paint pigments from the ICDD database to determine the crystalline phases in the paint.

A fast column extraction method coupled with a Hach colorimeter is a common method to measure lead content of drinking water in the field. In 1995 the EPA developed a method for field analysis of lead paint, dust or soil using a Hach colorimeter (24). The procedure was to weigh out exactly 0.100 g of the powdered sample. The sample was then placed in 5 ml of 25% lead-free nitric acid in a 50 ml plastic centrifuge tube, heated to 40°C, and sonicated for 30 minutes. The sample was diluted to 50 ml with deionized water and allowed to settle for an additional 30 minutes. Then 5 ml of the extract was taken and diluted to 1000-ml with deionized water. Exactly 100 ml of the solution was put through a Hach fast extraction column with lead content determined by a Hach-100 colorimeter. With each set of samples a standard and blank sample were also analyzed. The blank consisted of 0.100 g of Fisher titanic oxide, TiO_2. The standard consisted of 0.090 g titanic oxide and 0.010 g Fisher lead oxide, PbO.

To evaluate the effectiveness of the rapid acid digestion methods, the remaining 45 ml of each solution and residue solid was allowed to remain in the centrifuge tube for two months. This allowed the residue powder to be in contact with 2.5% nitric acid. Twenty-five ml of each sample was filtered and analyzed for lead with a Perkin Elmer ICP using lead standards of 25 and 100 ppm Pb. When needed samples were diluted so that the standards bracketed the lead content in the solutions. A 2.5% nitric acid blank was also analyzed.

RESULTS

Table I lists the year a building was built, the lead content and the crystalline phases. Lead content of paints ranted from 0.004 wt.% (40 ppm) to 10.8 wt.% (108,000 ppm) Pb. Examples of our results from samples collected from buildings on the State University of West Georgia with low lead contents include a sample taken from Alumni House, Old Auditorium, and Melson Hall. The exterior of the Alumni House (est. 1936) is representative of a modern "lead-free" paint with TiO_2 as the pigment. The X-ray analysis revealed the paint to contain synthetic rutile (TiO_2), synthetic quartz (SiO_2), synthetic calcite ($CaCO_3$), and synthetic gypsum ($CaSO_4 \bullet 2H_2O$). The sample contains 40 ppm lead. A sample from inside stairway of the Old Auditorium building (est. 1937) on campus contained synthetic rutile (TiO_2), synthetic quartz (SiO_2), synthetic anhydrite ($CaSO_4$), and synthetic calcite ($CaCO_3$). The sample contained 0.42 wt.% lead.

Table I. Crystalline phases and lead content of paints from west Georgia. All buildings except Rome and Carrollton are on the campus of the University of West Georgia.

Building	Year Built	Pb (wt.%)	Crystalline (synthetic) phases
Bonner House (e)	1843	4.39 (I) 4.75 (H)	Rutile, quartz, kaolinite, calcite, zincite, hydrocerussite, plattnerite or anatase
Kennedy Chapel (e)	1893	4.01 (I) 4.25 (H)	Rutile, quartz, calcite, zincite, barite, hydrocerussite
Kennedy Chapel (i)	1893	3.1 (H)	Rutile, quartz, zincite, calcite, anhydrite, anatase
Melson Hall (e)	1907	0.14 (H)	Rutile, calcite, anhydrite, barite
Honors House (e)	1907	7.13 (I) 7.25 (H)	Rutile, quartz, calcite, zincite, barite, hydrocerussite, plattnerite or anatase
Adamson Hall (e)	1918	2.76 (I) 2.94 (H)	Rutile, quartz, calcite, zincite, barite, hydrocerussite, talc, anatase, kaolinite
Alumni House (i)	1930	0.86 (H)	Rutile, quartz, calcite, gypsum
Alumni House (e)	1930	0.0* (H)	Rutile, quartz, calcite, gypsum
Mandeville Hall (e)	1935	4.01 (I) 3.25 (H)	Rutile, quartz, zincite, hydrocerussite, anglesite

Martha Munro (e)	1935	9.64 (I) 10.8 (H)	Rutile, zincite, anatase, talc, barite, hydrocerussite, anglesite
Old Auditorium (e)	1937	1.05 (I) 0.72 (H)	Rutile, quartz, zincite, anatase, talc, calcite
Old Auditorium (i)	1937	0.42 (H)	Rutile, quartz, anhydrite, calcite
Sanford Hall (e)	1938	7.72 (I) 7.25 (H)	Rutile, quartz, kaolinite, barite, zincite, talc, hydrocerussite, plattnerite or anatase
Sanford Hall (i)	1938	3.15 (H)	Rutile, quartz, calcite, barite, anatase, phoenicochroite
Continuing Education (e)	1947	2.9 (I) 2.9 (H)	Rutile, quartz, kaolinite, zincite, anatase, calcite, talc, hydrocerussite
Aycock Hall (e)	1952	3.07 (I) 3.25 (H)	Rutile, quartz, zincite, anatase, talc, anglesite
Geography (e)	1954	2.67 (I) 2.8 (H)	Rutile, quartz, zincite, anatase, kaolinite, barite, calcite, crocoite
Rome, GA (e)	1933	5.15 (H)	Rutile, quartz, zincite, calcite, hydrocerussite
Carrollton, GA (e)	1927	10.5 (H)	Rutile, quartz, zincite, calcite, talc, hydrocerussite, plattnerite or anatase
Carrollton, GA (B)	1927	4.1 (H)	Rutile, anatase, zincite, calcite, barite, hydrocerussite

(I) = ICP analysis
(H) = Hach colorimeter analysis
(i) = interior paint
(e) = exterior paint
B = Bath tube
* = 40 ppm Pb

Lead phases (synthetic) are anglesite $PbSO_4$, crocoite $PbCrO_4$, hydrocerussite $Pb_3(CO_3)_2(OH)_2$, phoenicochroite Pb_2CrO_5, and plattnerite PbO_2.

Non-lead phases (synthetic) are anatase TiO_2, anhydrite $CaSO_4$, barite $BaSO_4$, calcite $CaCO_3$, gypsum $CaSO_42H_2O$, kaolinite $Al_2Si_2O_5(OH)_4$, talc $Mg_3Si_4O_{10}(OH)_2$, quartz SiO_2, rutile TiO_2, and zincite ZrO.

Examples of samples with higher lead content include a paint sample taken from a janitor's closet in the basement of Sanford Hall (est. 1938). By X-ray diffraction analysis, the sample contained synthetic phoenicochroite (Pb_2CrO_4O), synthetic quartz (SiO_2), synthetic calcite ($CaCO_3$), synthetic barite ($BaSO_4$), synthetic anatase and rutile (TiO_2). The sample contained 3.15 wt.% lead. A sample from the outside of a home built in Rome, Georgia in 1933 contained the lead pigment synthetic hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), synthetic quartz (SiO_2), synthetic calcite ($CaCO_3$), synthetic rutile (TiO_2), and synthetic zincite (ZnO). The lead content of this paint is 5.15 wt.%. The X-ray analysis of a sample from a bathtub inside of a house in Carrollton, Georgia built in 1927 showed the paint to contain synthetic rutile and anatase (TiO_2), synthetic calcite ($CaCO_3$), synthetic zincite (ZnO), synthetic barite ($BaSO_4$), and synthetic hydrocerussite ($Pb_3(CO_3)_2(OH)_2$). The sample contained 4.1 wt.% lead. A sample from the outside of the previously mentioned house contained synthetic hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), synthetic rutile (TiO_2), synthetic calcite ($CaCO_3$), synthetic zincite (ZnO), synthetic quartz (SiO_2), synthetic talc ($Mg_3Si_4O_{10}(OH)_2$) and synthetic plattnerite (PbO_2) or synthetic anatase (TiO_2). The sample contains 10.5 wt.% lead. The highest lead content of the 21 samples of the study had 10.8 wt.% Pb. The sample was collected from the outside of Martha Munro (est. 1935) and contains synthetic rutile and anatase (TiO_2), synthetic zincite (ZnO), synthetic talc ($Mg_3Si_4O_{10}(OH)_2$), synthetic barite ($BaSO_4$), synthetic hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), and synthetic anglesite ($PbSO_4$).

DISCUSSION

Lead phases detected in lead paint include synthetic hydrocerussite, crocoite, anglesite, phoenicochroite and possible plattnerite. The common presence of synthetic hydrated hydrocerussite in these paints indicates that the lead is being hydrated as the paint weathers. This is important because the hydrated lead phases are more readily dissolved in stomach acid.

The EPA standard for lead in paint is that anything above 600 ppm, or 0.06 wt.% is hazardous. Only one of the 21 paint samples collected for this study (The Alumni House on the campus of UWG) has a lead content below 0.06 wt.%. Many old public and private buildings in the west Georgia region contain old lead paint that exceeds the allowable limit of lead in modern paint.

There were six samples that did not contain detectable lead phases by X-ray diffraction methods. These samples contained from 0.0 to 1.05 wt.% lead. A lead phase was detected on a sample with 2.67 wt.% lead. The detection level of lead in paint by X-ray diffraction methods is between 1.05 and 2.67 wt.% lead.

Figure 1 is a plot of ICP versus Hach colorimeter analysis of lead content of paint samples. The r^2 value 0.97 for the data indicates good correlation between the two methods of lead analysis. Thus the Hach colorimeter provides a rapid method for lead analysis that can be done on site. The similar results from the Hach colorimeter and ICP also indicate that the rapid digestion method developed for field-test method by Grohse et al. (24) works well to extract the lead from paint.

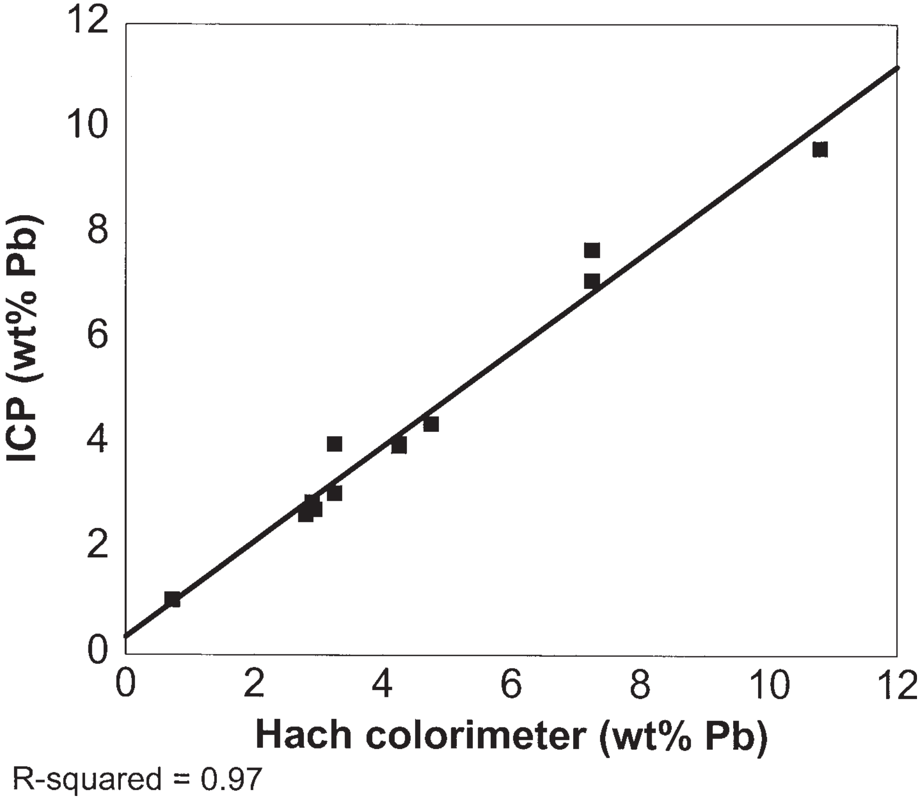

Figure 1. A plot of the measurement of lead in paint by ICP versus Hach colorimeter.

Lead contamination has been a problem that has plagued the human race for centuries. Figure 2 shows the typical "alligator pattern" that forms as lead-based paint containing 10.5 wt.% Pb weathers. Whenever this alligator pattern is encountered extreme care should be taken to protect adults and children from lead poisoning. Children are the most common recipients of lead poisoning. The risk assessment involved with the infestation of young children are: blood levels checked in children 6 months to 6 years of age is top priority, also, soil levels for yard and garden contamination, household dust, interior and exterior paints, drinking water, street dust, air and bath water. Children may also be dangerously affected by lead in dust, paint, and paint chips in schools, daycare, play areas, by cooking and eating utensils, imported canned food, antique toys, cribs and fishing sinkers. If the lead is coming from a rock source, it can be covered by natural sediment or removed by mechanical erosion. Lead in homes can be covered or removed by an EPA approved method. Risk assessment includes all factors involved with lead poisoning, but lead based paint is the greatest hazard of all factors (1-22). Homes built before 1980 should be checked for lead contamination. It is estimated that 75% of the houses build before 1980 have lead paint contamination. The results of this study indicate that many public buildings built before 1990 contain lead paint. There is a need for further and more intensive sampling of paint from these buildings.

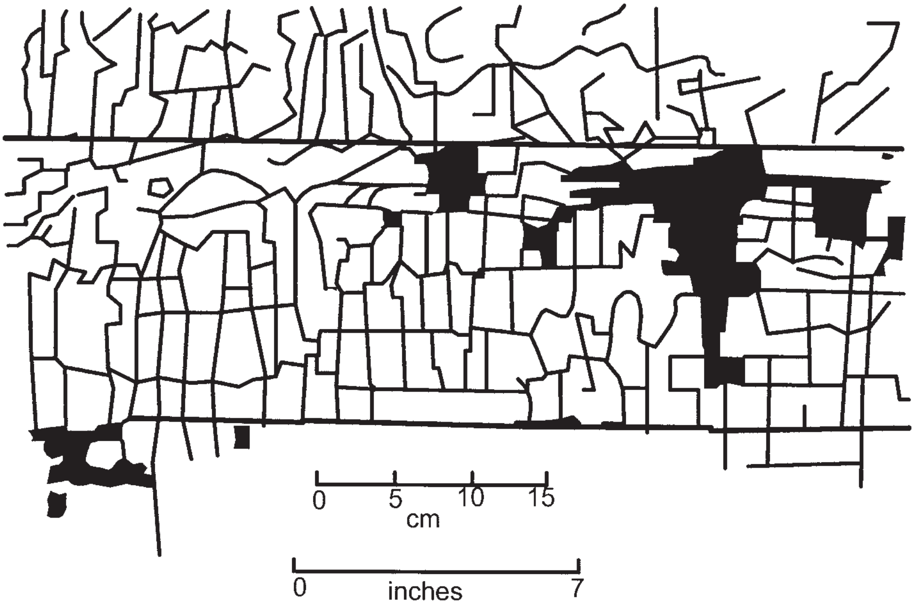

Figure 2. An example of the typical "alligator pattern" that commonly develops with deterioration of lead-based paints. The paint contains 10.5 wt.% Pb.

Our minimum sampling method of one exterior and one interior sample resulted in all but one building containing lead paint that exceeded the EPA permitted limit of 0.06 wt.% (600 ppm) Pb. A major concern we developed during this research project is for the well being of the painters employed to scrape and paint old public buildings. They need to be informed of the lead contents of paints on these buildings to protect the people working in the buildings, themselves, and their families (lead dust brought home on workers' clothing can be a significant source of lead poisoning to children).

In 1977, lead poisoning was mainly in inner city children. However, it is now considered a "yuppy disease" affecting the upper and middle class families living in older homes as they are remodeled.

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The photographic rendition of Dr. Herrington's graph had poor resolution [Vol. 57 (4), 1999].

Figure 3. Relationship between rainfall and the number of amphibians and reptiles (herps) and small mammals collected from May 1, 1996 through October 1, 1996.

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