

FLORIDA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

PROJECT FINAL REPORT

**UMBRELLA: MODELING APPROACHES AND EMPIRICAL STUDIES SUPPORTING
AATLSS**

**PROJECT: THE EFFECT OF EVERGLADES FOOD ITEMS (PREY) ON
CROCODILIAN GROWTH DEVELOPMENT, AND FERTILITY**

PRINCIPAL INVESTIGATOR: P. T. Cardeilhac

CO-PRINCIPAL INVESTIGATORS: O. L. Bass, W. R. Wolff, D. M. Fleming

RESEARCH WORK ORDER #: RWO 154b

FUNDING AGENCY: U.S. Geological Survey

PROJECT START DATE: 10/01/95 END DATE: 12/31/99

REPORTING PERIOD: FINAL REPORT

ABSTRACT:

Alligators are the top aquatic predators of the Everglades National Park (park), and unlike birds, they essentially do not migrate (8). Reproductive parameters of an alligator population are characteristic for a lake or area of habitat and remain relatively constant unless there is a change in the environmental status (1,11,14,15,19). The nutrient plane or prey-base of an area is known to affect reproductive parameters of the alligator population (1,2,3,6,7,10,13,14,15,16,19). Thus, an evaluation of the reproductive status of the alligator population in the park is also an evaluation of its environmental status and prey-base (1,11,14,15,19). However, capturing and evaluating a sample of adult alligators from an area the size of the Everglades National Park (500,000 acres) may not be practical or desirable; while, determining reproductive potential and egg parameters for this population can easily be done with a minimum of disturbance (6). Reproductive potential, egg parameters and the growth performance of hatchlings have been determined over a 5-year period for the park. Egg parameters have been determined over a 12-year period for Southwest Louisiana (Rockefeller Refuge) which was considered to be a stable, highly productive control area. Egg parameters for Lake Griffin in Central Florida have been monitored over a 12-year period and it was included in our study because it underwent severe environmental changes between 1994 and 1997 and many of the effects of these changes on reproductive parameters were monitored. Reproductive potential and egg parameters have been found to be characteristic and relatively constant for the park and Southwest Louisiana; however, changes in the environmental status, as occurred on Lake Griffin in 1996 and 1997 caused changes in these values that were readily detectable (11).

Our initial studies on Everglades-alligators have shown significant differences in size and shape of the eggs produced in the park and the hatchlings produced are significantly smaller than those from control areas (6). However, growth performance of the hatchlings does not appear to be significantly different from control animals (6). It has also been determined that median values for body condition of the adults is poor and clinical values of the animals indicate anemia and chronic inflammation in at least some of the animals (9,16). Studies on feeding wild-caught alligators, the nutrient composition of prey and the presence of nutrients and contaminants in alligator egg yolks have indicated that these clinical signs are caused by nutrient deprivation (9,12,13,16,17,18).

The effect of nutrient deprivation and water levels strongly influence the reproductive rate, growth performance and energy requirements of the population. The evaluation variables determined in our study provide critical data to support the National Biological Service's "Across Trophic Level System Simulation (ATLSS)" project to develop an individual based American alligator model (4). The experimental design (n values from 12 to 90) gave confident ($\alpha < 0.05$) estimations of the evaluation variables for a single year using the moving median method (15). However, the moving median method and fluctuations in water levels require that data be collected over several years (11,14,15) to provide Everglades evaluation variables with a margin of error suitable for a reliable model which will allow planners to predict the effects of water levels on the alligator population (4). The normal values for variables were determined and monitored by the moving median method over the 5-year study period.

Literature & Reports Cited:

1. Cardeilhac P. T. Diagnosis and Treatment of Infertility in Captive Alligators. Final Reports for the Aquaculture Market Development Aid Program. Vol I - III. 1987 - 1991. Florida Dept. of Agriculture, Tallahassee, FL 32399-0810.
2. Cardeilhac, P. T. Annual Reports on Husbandry Research, 1991 - 92 Florida Game & Fresh Water Fish Commission, Tallahassee, FL 32399 – 1600
3. Millstein S. R., Vander Meer R. K., Schoenagle E. M. and Cardeilhac P. T. Dietary Therapy for Egg Fertility in the American Alligator: An Evaluation by Determining Fatty Acid Profiles of Egg Yolk. Proceedings International Association for Aquatic Animal Medicine. vol 25 pp 10 - 15, 1994.
4. Wolff, W. R. An individual-oriented model of a wading bird nesting colony. A Model Prepared for Environmental Sciences Division Oak Ridge National Laboratory and The Institute for Environmental Modeling Department of Mathematics University of Tennessee.
5. Barnett J..D. and P. T. Cardeilhac. (1995) A Survey of Opportunistic Bacterial Diseases in Farm Raised Alligators. Abstract 10 Abstract Book Animal Disease Research Workers in Southern States. March 5 – 7.
6. Cardeilhac, P. T. ,Fleming M.O. and Bass O.L. (1996). An Evaluation of Egg Quality and Hatchling Growth Potential for American Alligators in the Southern Everglades. Proceedings International Association for Aquatic Animal Medicine Vol 27 pp 72-76.
7. Heaussner, E.L., Vander Meer, R.K. and Cardeilhac P. T. (1996) Effects of Alligator Egg Yolk Long-Chain Fatty Acids on Growth Performance of Hatchlings. Proceedings International Association for Aquatic Animal Medicine Vol 27 pp 77-82.
8. Barnett, J., Rice, K., Perceval, H.F., and Cardeilhac P.T. (1997) A Method for the Intramuscular Implantation of Transmitters in Alligators. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 45-48.
9. Barnett, J., Fleming, M.O., Wolfe W., Barr, B. and Cardeilhac, P. T. (1997) Evidence for Chronic Inflammation in Alligators from the Southern Everglades. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 49-52 .
10. Cardeilhac P. T., Barnett J. Woolesy, L. J. (1997) Four Alligator Feeds Produced from Spent Laying Hens. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 109-116

11. Cardeilhac, P.T. Winternitz D.L., Barnett J.D., Froelich E., Foster K.O., Ashley, J.D. VanderMeer, R. (1998) Declining Reproductive Potential of the Alligator Population On Lake Griffin in Central Florida. Proceedings International Association for Aquatic Animal Medicine, Vol. 29, 30-37.
12. Barnett J.D. and P.T. Cardeilhac. (1998) Brown Spot Disease in the American Alligator. Proceedings International Association for Aquatic Animal Medicine, Vol. 29, 124-125.
13. Barnett, J.D., Cardeilhac P.T. Barr B., Wolff, W. Bass, O.L. Fleming, D. M. Utilization of thyroid hormone levels to determine starvation in southern Everglades alligators. Proceedings International Association for Aquatic Animal Medicine, Vol. 29, 52-56.
14. Cardeilhac, P. T. Winternitz, D. Barnett J. D., Bass O.L., Wolff, W.R. (1999) The American Alligator as a Sentinel for the Environmental Status of Southern Wetlands. Proceedings International Association for Aquatic Animal Medicine. 3069-70.
15. Cardeilhac P. T. , Winternitz D. L., Barnett J. D., Bass, O. L. Wolff, W.F. (1999) The Moving Median Method to Estimate Normal Egg Parameters for Alligator Populations in the Southern Everglades, Southwest Louisiana, and Lake Griffin Proceedings International Association for Aquatic Animal Medicine. 155-159.
16. Barnett J. D. Cardeilhac P. T. Barr B. and Wolff, W., Bass O. L. (1999) Differences Between Captive-Raised and Wild-Caught Everglades National Park Alligators in Serum Chemistry Values, Serum Protein Electrophoresis, Thyroid Hormone Levels and Complete Blood Counts. Proceedings International Association for Aquatic Animal Medicine. 30: 136-140.
17. Barnett, J. D. Cardeilhac, P. T. Aguilar R. (1999) Necropsy of a Leucystic American Alligator. Proceedings International Association for Aquatic Animal Medicine. 30: 149-157.
18. Cardeilhac, P. T., McClellan W. M., Cardeilhac J. P., Dixon, H. M., Barnett, J. M., Barr, B. Wolfe W. R., Bass, O. L. and Fleming M. D. (2001) The Source of Nutrients and Contaminants of Alligators in the Everglades National Park. Proceedings International Association for Aquatic Animal Medicine. 32: 69-70. p 3.
19. Dixon, H. M. and Cardeilhac, P. T. PIX: A New Skin Disease of Alligators. Abstracts from the 53rd Meeting Dickson Animal Disease Research Workers of the Southern States. Feb 10-12 2001. Abstract 10.

OBJECTIVES:

1. Determine the nutritional quality of the top 7 prey items for the alligator population of the Everglades National Park and identify the presence and concentration of major contaminants (18).
2. Determine normal values to evaluate and monitor the status of the alligator population of The Everglades National Park for the following variables:
 - a. reproductive potential (1),
 - b. egg parameters (1,4)
 - c. yolk nutrients such as fatty acid profiles (5)
 - d. yolk contaminants (18)
 - e. embryonic development (6)
 - f. teratology (6)
 - g. hatchling growth performance (1,4)
3. Quantify the health status of the alligator population in the Everglades National Park and identify the cause(s) of poor body condition and anemia (9,13,16,18).

Rational

Nest monitoring at the Everglades National Park has shown that mean water levels in the park are closely correlated with nest production by the alligators. It is known that reproductive potential of the alligator is related to food quality and availability (1,2,3,6). However, the detailed effects of water levels on the availability of prey, its quality as a food item, the presence or absence of toxins or parasites and the resulting effect on fertility and health status are not known. Previous work on the alligator has shown that critical nutrients in the alligator diet effect health status, growth and specific reproductive parameters (1,2,3,6). It has been shown that fatty acid profiles of fat in the diet effects egg fertility, embryonic survival and hatchling vigor (1,2,3,6). Knowledge of prey availability, quality and composition is necessary to predict (4) its effect on health status, fertility, growth and development in the alligator population of the Everglades. Conversely, the reproductive status, body condition and health of the alligator population indicate the environmental status of the park. Therefore, the effect of water levels and other environmental factors on prey availability and its food value is necessary to predict (4) its effects on health status, growth, embryonic development and reproductive performance. With appropriate data, the effects of water levels on nest-rate, clutch size, percent fertile eggs, embryo survival, hatch rate and hatchling vigor could be predicted (4) by change in types of prey available, quantities, quality and their potential as a source for toxins, parasites and pathogens. Quality or biological value of the dietary protein depends on its digestibility, amino acid profiles and the presence of sufficient energy for its utilization (1,2,9). Toxins and/or parasites in the prey can, of course, affect all parameters (13,14,15). Therefore, any predicted effect of nutrient status of the habitat should be confirmed by monitoring body condition, health status and breeding condition of the population. Body condition and health status of the alligator population are evaluated by measuring parameters such as death rates (size-gender-puberty etc. profiles) physical

condition, morphometrics, clinical values, pathology and microbiology. Reproductive potential of the population is evaluated by a determination of reproductive parameters such as nest rate, eggs per nest, egg quality, percent fertile (banded) eggs, embryo survival, hatch rate and hatchling vigor. These parameters are measured as quantitative evaluation-variables. This project develops methods to accurately determine these variables, monitor them and compare them with control samples. The results provide the potential to construct a more accurate predictive model (4) for the effects water levels and other environmental effects on reproductive potential, embryonic development, reproductive performance and growth rate of the alligator.

FINAL PROGRESS STATEMENT:

Samples of approximately 180 eggs from about 30 different nests were randomly collected annually in the Everglades National Park from 1995 to 2000. Mean clutch size for the park was determined by the moving median method to be 24.3 eggs (S. D. 0.79 eggs) per nest. Three fertile and three infertile eggs were collected from each nest, if possible. Therefore, approximately half of the eggs were determined to be infertile or had very early embryonic death (VEED). Hatch rate (86%) for the fertile eggs and stage of embryonic development at death (94% died before developmental day 10) were recorded. Teratology in the in the hatchlings or dead embryos was also investigated. A sample of 144 fertile eggs and approximately an equal number of infertile eggs collected from nests on the Rockefeller Refuge in Louisiana (ROK-eggs) were used as controls. Egg statistics and growth performance were determined for both experimental and control hatchlings (15). Normal values and their standard deviations were determined for 35 egg statistics (6) using the moving median method (15). Normal values for the park were compared with values for the Rockefeller Refuge and with values obtained from 15 areas (lakes and farms) over 14 years. The normal value for each variable were determined using the moving median method (15). The comparisons involved the 35 factors determined in over 9,000 observations. Nine (9) animals from the Everglades National Park were captured and brought to the University of Florida, College of Veterinary Medicine aquatic animal research laboratory for a 4-month study before return to the park. Fecal examinations were done and blood was collected every 2 weeks from these animals. Serum chemistry, protein electrophoresis, complete blood counts (CBC), and thyroid hormone profiles were determined. Weights and lengths of the animals were also measured. Comparisons of the wild-caught to captive-raised animals showed significant differences in several blood values. The wild-caught animals were also found to be anemic when compared to genetically-similar control animals. Significant disease problems could not be detected in the wild-caught alligators. Clinical values of the wild-caught animals moved towards the genetically-similar control animals after they received a high-quality diet. It was concluded that health problems of the wild park alligators was caused by nutrient deprivation.

PROJECT SUMMARY STATEMENT:

An evaluation of the physiological status of the alligator population in a lake or area of habitat is also an indication of its environmental status. In this study, a method for the determination and monitoring of normal egg parameters and quality of the prey-base for the alligator population of the Everglades National Park over a 5-year period is described.

KEYWORDS: 1.Alligators 2. Prey 3.Nutrition, 3. Contaminants 4. Health 5. Eggs
6. Shell 7.Yolk 8. Clinical Values

PUBLICATIONS:

1. Millstein S. R., Vander Meer R. K., Schoenagle E. M. and Cardeilhac P. T. (1994) Dietary Therapy for Egg Fertility in the American Alligator: An Evaluation by Determining Fatty Acid Profiles of Egg Yolk. Proceedings International Association for Aquatic Animal Medicine. vol 15.
4. Cardeilhac, P.T. A Color Atlas of Diseases of Crocodiles. A Book Review for The International Association for Aquatic Animal Medicine Newsletter. Vol 26 Number 1, January 1995.
5. Barnett J.D., Cardeilhac.P.T. (1995) Clinical Values Associated with Opportunistic Bacterial Diseases in Farm Raised Alligators. Proceedings of the International Association for Aquatic Animal Medicine. Vol 26 pp 22,
6. Barnett J..D. and P. T. Cardeilhac. (1995) A Survey of Opportunistic Bacterial Diseases in Farm Raised Alligators. Abstract 10 Abstract Book Animal Disease Research Workers in Southern States. March 5 – 7.
7. Larsen, R.E. and Cardeilhac P.T. (1996) Collection of Spermatizoa from Leucistic (White) Alligators. Proceedings of the International Association for Aquatic Animal Medicine. Vol 27 pp 83 - 86
8. Garrett, F.M. Marshall, K. Barnett J.D. and Cardeilhac P.T. (1996) Fatal Aeromonas Infection in an Albino American Alligator. Proceedings of the International Association for Aquatic Animal Medicine. Vol 27 p53.
7. Cardeilhac, P. T. ,Fleming M.O. and Bass O.L. (1996). An Evaluation of Egg Quality and Hatchling Growth Potential for American Alligators in the Southern Everglades. Proceedings International Association for Aquatic Animal Medicine Vol 27 pp 72-76.
8. Heaussner, E.L., Vander Meer, R.K. and Cardeilhac P. T. (1996) Effects of Alligator Egg Yolk Long-Chain Fatty Acids on Growth Performance of Hatchlings. Proceedings International Association for Aquatic Animal Medicine Vol 27 pp 77-82.
9. Barnett, J., Rice, K., Perceval, H.F., and Cardeilhac P.T. (1997) A Method for the Intramuscular Implantation Of Transmitters in Alligators. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 45-48.

10. Cardeilhac P. T., Barnett J. Woolesy, L. J. (1997) Four Alligator Feeds Produced from Spent Laying Hens. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 109-116109 - 116.
11. Barnett, J., Fleming, M.O., Wolfe W., Barr, B. and Cardeilhac, P. T.(1998) Evidence for Chronic Inflammation in Alligators from the Southern Everglades. Proceedings International Association for Aquatic Animal Medicine Vol 28 pp 49 - 52.
12. Barnett J.D. and P.T. Cardeilhac. (1998) Brown Spot Disease in the American Alligator. Proceedings International Association for Aquatic Animal Medicine, Vol. 29, pp 124 - 126
13. Barnett, J.D., Cardeilhac P.T. Barr B., Wolff, W. Bass, O.L. Fleming, D. M. Utilization of Thyroid Hormone Levels to Determine Starvation in Alligators from the Everglades National Park (1998) Proceedings International Association for Aquatic Animal Medicine Vol 28 pp52-56.
14. Cardeilhac, P.T., Winternitz D.L., Barnett J.D., Froelich E., Foster K.O., Ashley, J.D. VanderMeer, R. (1998) Declining Reproductive Potential of the Alligator Population On Lake Griffin in Central Florida. Proceedings International Association for Aquatic Animal Medicine, Vol. 29, pp 30 - 36.
15. Cardeilhac, P. T. Winternitz, D. Barnett J. D., Bass O.L., Wolff, W.R. (1999) The American Alligator as a Sentinel for the Environmental Status of Southern Wetlands. Proceedings International Association for Aquatic Animal Medicine. 30: 69 - 70.
16. Barnett J. D. Cardeilhac P. T. Barr B. and Wolff, W., Bass O. L. (1999) Differences Between Captive-Raised and Wild-Caught Everglades National Park Alligators in Serum Chemistry Values, Serum Protein Electrophoresis, Thyroid Hormone Levels and Complete Blood Counts. Proceedings International Association for Aquatic Animal Medicine. 30: 136 - 140.
17. Barnett, J. D. Cardeilhac, P. T. Aguilar R. (1999) Necropsy of a Leucystic American Alligator. Proceedings International Association for Aquatic Animal Medicine. 30: 149 - 151.
18. Cardeilhac P. T. , Winternitz D. L., Barnett J. D., Bass, O. L. Wolff, W.F. (1999) The Moving Median Method to Estimate Normal Egg Parameters for Alligator Populations in the Southern Everglades, Southwest Louisiana, and Lake Griffin Proceedings International Association for Aquatic Animal Medicine. 30: 155 - 159.
19. Cardeilhac, P. T., McClellan W. M., Cardeilhac J. P., Dixon, H. M., Barnett, J. M., Barr, B. Wolfe W. R., Bass, O. L. and Fleming M. D. (2001) The Source of Nutrients and Contaminants of Alligators in the Everglades National Park. Proceedings International Association for Aquatic Animal Medicine. 32: 69-70. p 3.

20. Dixon, H. M. and Cardeilhac, P. T. PIX: A New Skin Disease of Alligators. Abstracts from the 53rd Meeting Dickson Animal Disease Research Workers of the Southern States. Feb 10-12 2001. Abstract 10.

INVITED PRESENTATION CITATIONS: (1995 - 2000):

1. "Alligator Health Update" Southern Animal Health Association Meeting, May (2001).
3. "Alligator Husbandry and Medicine Update" Florida Fish and Wildlife Conservation Commission Meeting April (2000).
4. "Marine Mammals and Reptiles" Life in the Sea Florida State University (Curricula for Oceanography, Panama City)
5. Interdisciplinary Reproductive Biology Group, University of Florida (February 1999) "The Use of Alligator Egg Parameters to Monitor the Environmental Status of Habitat".
6. Pathobiology Research Seminars, Department of Pathobiology University of Florida. Declining Reproductive Potential of Lake Griffin In Central Florida".
7. Florida Aquaculture Association Conference, November 9 – 12, 1997 (at Disney's Coronado Springs Resort). Subject: "An Overview of Current Practices in Alligator production".
8. Aqua Med Course, Texas A&M University, June 1990-2000 (Course Instructor) Subject: "Health Management of the American Alligator".
9. "Fish Nutrition". Diseases of Warmwater Fish course, Department of Fisheries & Aquatic Science University of Florida (June 1996-98)
10. "Fish Nutrition". South Florida Tropical Fish Growers Homestead Florida (March 1996).
11. Japanese Feed Team. (September 1995) Subject: "Nutrition, Feed Management and Production Techniques for the American Alligator". Presentations at Gatorland Zoo, Orlando and at the University of Florida campus.
12. "Nutritional and Reproductive Studies on the American Alligator". (October 1995) Universidad Juarez Autunoma De Tobasco. Villahermosa, Tobasco, Mexico.
13. "Recent Nutritional and Reproductive Research on the American Alligator and Proposed Research on the American Eel". (Dec. 1995) China External Trade Development Council Taipei, Taiwan R.O.C.

THESES/DESSERTATIONS CITATIONS: NONE

EMPLOYMENT STATUS OF GRADUATED STUDENTS: NONE

HONORS/AWARDS: NONE

PERSONNEL:

YEAR (1995 -1999)

NAME	POSITION	GRADUATED	GENDER	ETHNICITY
Sheri Millstein DVM	DVM Student	YES	F	C
James D. Barnett DVM	DVM Student	YES	M	C
Edward L. Haeussner DVM	DVM Student	YES	M	C
Kemba Marshall	DVM Student	NO	F	B
Dianna Winternetz	DVM Student	NO	F	C
Wayne McClellen	Senior Lab Tech	---	M	B
Joseph P. Cardeilhac	Part Time (OPS)	---	M	C
Angelica Welsh	Part Time (OPS)	Yes	F	C
Liza Hearon	Student Science Training No		F	C
Theresa Floyd	Student Assistant	NO	F	C

NEWS MEDIA INVOLVEMENT: NONE