University of South Bohemia

Faculty of Science

Long-term trends in fledging success of some Ardeidae

Bachelor thesis

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Annotation:

I have searched 92 papers for data on reproductive parameters. I have used Generalized Linear Mixed Models to test factors affecting the mean number of fledged chicks of eight species of Ardeidae family. I have tested three factors: start year of the study, habitat and diurnal/nocturnal activity.

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Acknowledgements

Content:

1. Introduction

Bird reproductive success is usually estimated using parameters such as clutch size, brood size and number of fledged offspring. Clutch size is defined as the number of eggs laid in a single nesting. Brood size is the number of nestlings, which successfully hatch. Number of fledged offspring is the number of nestlings which survive until they are able to leave the nest. These parameters may vary considerably in space and time (Ricklefs 1969). However, to explain this large scale variability, most attention has been paid to clutch size (~ the most easily obtainable dataset), and other parameters have often been overlooked. Obvious reasons for the lack of meta-analyses on net reproductive output may be high complexity of possible effects to broods in nature and inability to gather detailed data on studied populations.

Our knowledge of large-scale geographical trends in bird reproductive success is still incomplete. To date, many studies have focused on a single relationship between the clutch size and latitude. It was found that birds from higher latitudes have generally larger clutch sizes than their counterparts from lower latitudes (e.g. Payne 1976, Koenig 1984, Young 1994). Several hypotheses have been proposed to explain this trend (Skutch 1949, Ashmole 1963, Cody 1966). According to Skutch (1949), latitudinal increase in clutch size is caused by higher predation in the tropics, which makes it more difficult for parents to deliver food to nestlings due to increased time spent patrolling the nest. Ashmole (1963) explained this trend in latitudinal differences as due to resource variation. Finally, Cody's (1966) hypothesis proposes that due to higher competition rates in the tropics, species living there should be more K-selected.These hypotheses have been tested in several landbird groups (Falconiformes Carrillo and Gonzáles-Dávila 2009, Passeriformes Anderson 1994, Styrsky et al. 2005, Porkert and Zajíc 2005, Strigiformes Donázar 1990), but rarely on waterbirds (but see study on Sternidae by Hockey and Wilson 2003). Clutch size is the most easily obtained and therefore the most widely used reproductive parameter in birds, but its use has severe limitations. Firstly, in many bird species clutch size is fixed. Secondly, clutch size does not reflect neither fledging success nor nestling mortality and therefore its use as an indicator of reproductive success is spurious. For this reason, conservation biologists are more likely to be interested in brood size and number of fledged offspring, rather than in clutch size, to predict trends in population sizes. Moreover, conservation biologists are more likely to be interested in net reproductive output trends than simple information on clutch

size. This is because final reproductive success better predicts trends in population size changes than its subset.

Reproductive output in Ardeidae is known to reflect environmental changes. Ardeidae herons are considered to be environmental bioindicators due to their role of top-predators (Kushlan 1993). Reproductive success in colonial waterbirds can be influenced by a number of environmental variables and, physiological and behavioural traits (Burger 1982, Frederick and Collopy 1989, Ranglack et al. 1991, Parsons et al. 2001). To date, the most comprehensive study, published by Rubolini and Fasola (2008), analysed data (72 papers) on clutch size and brood size in Nearctic egrets and herons. Besides an obvious poleward increase in clutch size they recorded a latitudinal decrease in brood size in some species. The authors explained this result as a combination of environmental (temperature, seasonality, unpredictability of food resources) and behavioural (cannibalism, „insurance" eggs) factors. Unfortunately, the authors did not payattention to temporal trends in the reproductive parameters. Due to their role as top predators, Ardeidae herons are considered to be useful environmental bioindicators and their reproductive success is therefore likely to reflect long term trends in environmental pollution.

In this study, we revise these patterns using a pooled dataset from eight species of Old World and New World Ardeidae, based on papers published between 1955 and 2010. We have evaluated the effect of selected environmental and behavioural parameters on the mean number of fledged offspring. We have also included a simple factor, the start year of the study, to describe possible long-term trends.

2. Methods

We have searched 92 studies on the reproductive parameters of eight Ardeidae species (see Appendix, Black-crowned Night-heron *Nycticorax nycticorax*, Cattle Egret *Bubulcus ibis*, Great Blue Heron *Ardea herodias*, Great Egret *Casmerodius albus*, Grey Heron *Ardea cinerea*, Little Blue Heron *Egretta caerulea*, Little Egret *Egretta garzetta*, Snowy Egret *Egretta thula*). Another twelve species were excluded due to a low amount of material (data from less than 15 colonies were not used due to low number of repetitions) (Boat-billed Heron *Cochlearius cochlearius*, Chinese Pond-Heron *Ardeola bacchus*, Great Bittern *Botaurus stellaris*, Green Heron *Butorides virescens*, Indian Pond-Heron *Ardeola grayii*, Intermediate Egret *Mesophoyx intermedia*, Least Bittern *Ixobrychus exilis*, Purple Heron *Ardea purpurea*, Reddish Egret *Egretta rufescens*, Squacco Heron *Ardeola ralloides*,

Tricoloured Heron *Egretta tricolor*, Yellow-crowned Night-heron *Nyctanassa violacea*). However, we were not able to extract data on clutch size for more than half of these studies. Therefore, we ran the models for mean number of fledged chicks per nest, this is even better for estimating long-term population trends. Further, we extracted data on the start year of the study, total length of the study (years), country, latitude, freshwater / saltwater / estuarine habitat (0-2), and diurnal / nocturnal activity (0-1). According to Rubolini and Fasola (2008), we defined fledging success as the mean number of chicks more than 10 days old. For multi-year studies, we calculated overall mean number of fledged chicks across all years forthe particular study. We included data on fledged chicks for all nests in the colony, not only for successful nests (although it was zero). Latitude was calculated as an absolute value of distance from the equator to enable comparison of data from both hemispheres. Ecological data (diurnal / nocturnal activity) were taken from Kushlan and Hancock (2005).

We performed the Generalized Linear Mixed Model (GLMM) using R software to evaluate the effect of the chosen factors on the mean number of fledged chicks. We used gaussian linear mixed effect regression (lmer function, Table 1) and statistical significance was obtained by comparing two consecutive models (anova function). Factors were selected using forward selection based AIC criterion. Factor latitude was positively correlated with factor start year of the study ($r_s = 0.12$, $P < 0.05$) and factor total number of years of the study was correlated with mean number of fledged chicks ($r_s = 0.03$, $p < 0.05$). Therefore, we eliminated these factors from the independent variable list. Further, we used bird species, total number of study years and number of observed nests as a random factor in our null model. We used three fixed factors: (1) start year of the study, (2) habitat, (3) diurnal / nocturnal activity. Separate analyses for each species were calculated using Multiple Regression (STATISTICA v. 8 software). Additionally, we computed Spearman rank correlations between start year of the study and latitude for Great Blue Heron and Cattle Egret.

3. Results

GLMM analysis showed a declining trend in the mean number of fledged chicks during the second half of the 20th Century (Table 1, Fig. 1). Separate analyses for each species showed this trend was significant only for Great Blue Heron (beta = -0.32, P = 0.0001) and Cattle Egret (beta = -0.51, P = 0.0104) (Fig. 2). In these species, the correlation between start year of the study and latitude were not significant (Spearman rank correlation; Great Blue Heron

$r_s = 0.04$, P > 0.05; Cattle Egret $r_s = 0.07$, P > 0.05). In other species, the relationships between start year of the study and mean numbers of fledged chicks were not significant (P at least 0,4). We also found a significant difference between the mean numbers of fledged chicks in relation to habitat (Table 1). The highest reproductive output was recorded for populations inhabiting freshwater areas (Fig. 3).

Table 1. Results of GLMM analysis after formula „mean fledged offspring number ~ + (1|n)+(1|species)+(1|total years)".

Tested variable	d.f.	Deviance	Deviance decrease	% of explained variability	AIC	Beta	P
Null	349	2111			2122		
Start year	348	2100	11	0.5	2112	-0.98	< 0.0001
Start year + habitat	347	2078	22	1.0	2086		< 0.0001
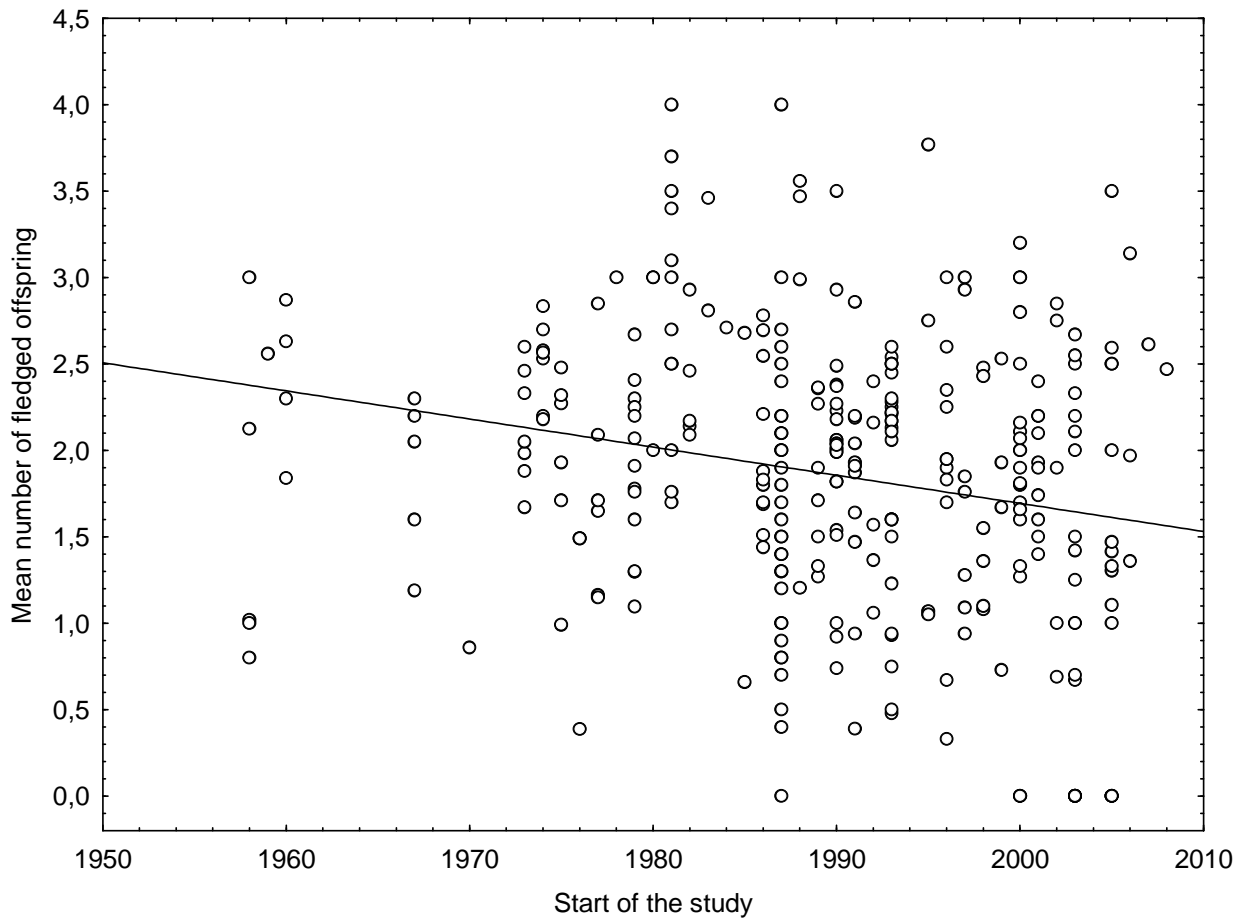
Figure 1. Mean number of fledged chicks according to start year of the study for all species.
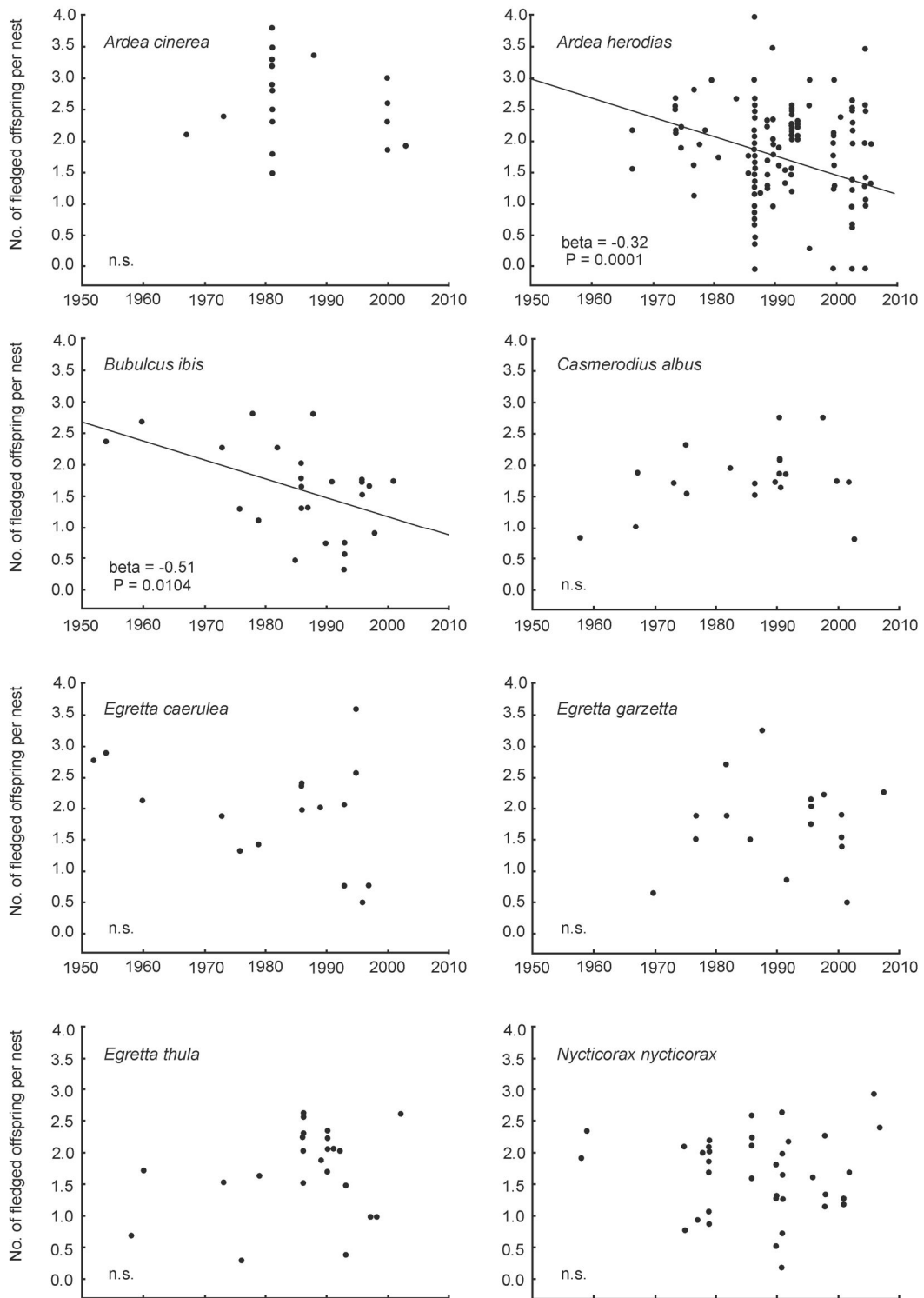
Figure 2. Mean number of fledged chicks according to start year of the study for each species separately using Multiple regression.
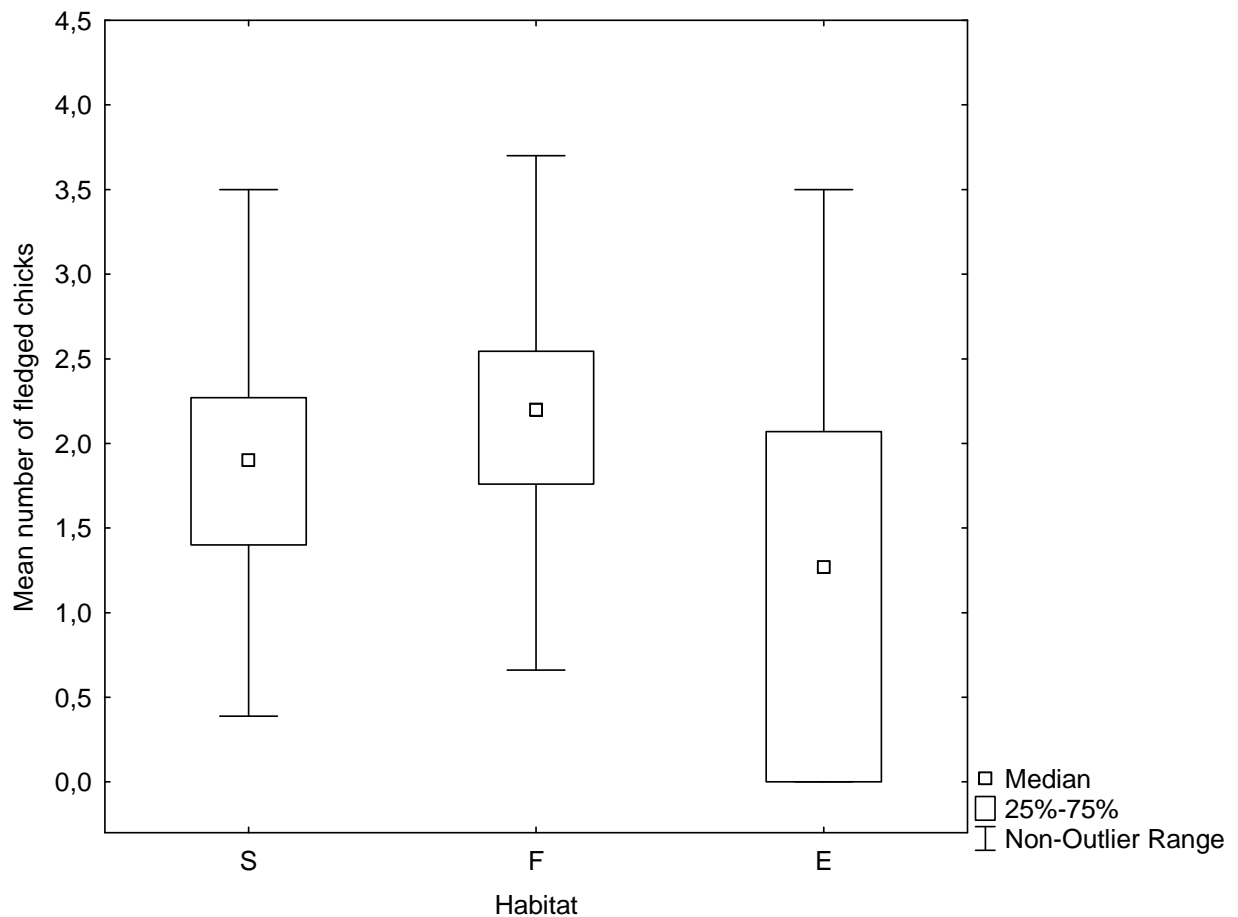
Figure 3. Effect of habitat on mean number of fledged chicks. F – freshwater habitat, S – saline habitat, E – estuarine habitat.

4. Discussion

Rubolini and Fasola (2008) reported poleward decreasing reproductive output for some Nearctic Ardeidae species. Although, they did not define which species showed this negative trend, the authors explained decreased productivity at high latitudes using several suggestions: (1) inability to feed a full brood due to unpredictability of food resources, (2) increased cannibalism among siblings and increased probability of becoming non-reproductive helpers, (3) the value of marginal siblings as „insurance" chicks against losses caused by stochastic events or intrinsic abnormality of core siblings. Based on our enlarged dataset, we can not confirm this trend in any of the tested species. Surprisingly, our analyses revealed that the start year of the study is the most significant factor affecting reproductive output in Ardeidae. Another factor that had a significant effect was habitat.

In particular a long-term decrease in reproductive output was found in Great Blue Heron and Cattle Egret. To our best knowledge, this is the first study reporting such a long-

term reproductive decrease in these obvious and widely distributed species. However, other questions arise from these results. Firstly, such a result can be an artefact of correlation among tested factors. During the first overall analysis, we found a significant correlation between the start year of the study and latitude. However, this result disappeared when we tested this relationship for the two mentioned species separately. Therefore, we rejected the suggestion that our results could have been influenced by inter-factor correlations. Other sources of bias can not be decreased reliability for our dataset, because of the difficulties in determining reproductive success exactly. For example, if birds successfully renest (which can take place after relocation to a different site/colony) following an initial attempt and are unmarked, reproductive success of the population would be underestimated (Erwin and Custer 1982). Fledglings' survival is also hard to estimate, because young herons and egrets can move away from the nest very early. In an ideal case the researcher would be able visit the colony daily. On the other hand, repeated nest checking can provoke abandonment of newly-constructed nests and intensified predation of nest contents (Tremblay and Ellison 1979), which will ultimately reduce reproductive success. Based on these facts, we can not exclude the existence of small biases in our dataset.

The most considerable long-term decline in mean number of fledglings per nest occurred in Great Blue Heron (*Ardea herodias,* Linnaeus 1758) which is the largest heron in North America. It breeds throughout much of North America except for in high mountains and deserts, in Central America, and on certain islands in the Caribbean and Pacific. Nesting Great Blue Herons require tall trees with some isolation from human disturbance and nearby aquatic areas. Being a top predator, Great Blue Herons accumulate persistent toxins, but population effects have not been shown so far and individual effects are subtle (Kushlan and Hancock 2005). Organochlorine pollutants generating eggshell thinning have been intensively studied since 1990s (Blus et al. 1980, Custer et al. 1983, Findholt and Trost 1985). Heavy metal concentrations became more studied in the last decade (Rumbold et al. 2001, Jungsoo and Tae-Hoe 2007, Pietrelli and Biondi 2009). Although our literature resources contain many studies concerning data on the effect of environmental contaminants to fledging success in Great Blue Heron none of studies have revealed a direct impact on heron reproduction. Only Harris et al. (2003) found an inconsistency in Great Blue Heron productivity in colonies around pulp mills, but no evidence for a clear effect of chlorinated hydrocarbon contaminants on nest success in the Strait of Georgia colonies as whole. In this study, the authors propose predation on eggs as a reason for poor reproductive success. Similarly Blus et al. (1980) found no evidence to relate organochlorine residues to adverse

effects on the reproductive success of Great Blue Herons in the Columbia Basin, and suggested that the apparent population decline was related to a shortage of trees suitable for nesting. This is in accord with Burkeholder and Smith (1991) who found that the number of young fledged each year declined as the size of the colony decreased. Butler et al. (1995) found significant positive correlation between fledging success and the number of years a colony had been in use. Therefore, stability of heron colonies appears to have a crucial impact to their reproductive success. Colonial nesting birds are more productive in large synchronised colonies (Alexander 1974). This phenomenon is frequently explained by reduced predation (Ward and Zahavi 1973). Unfortunately, we can not reveal the impact of any of above mentioned factors on Great Blue herons´ productivity due to a lack of such complex information.

Cattle Egret (*Bubulcus ibis*, Linnaeus 1758) is the most widespread and abundant heron species. Historically, its breeding range was limited to tropical and subtropical Africa, the species has expanded to all continents during the last two centuries. Cattle Egret has a varied diet, but mainly feeds on insects. Reasons for a long-term decrease in reproductive output in this species are hard to suggest. McKilligan (1997) identified reduced rainfall as a major cause of mortality due to starvation. He found, that good spring rainfall promotes growth of pasture grasses, which is favorable for the growth of major prey (Acrididae) populations and larger nymphal body weights. In another study (McKilligan 1985) he states, that in Australia the Cattle Egret may not be able to sustain its present breeding performance due to over-filling of its niche. Ranglack et al. (1991) suggested the same explanation for North American populations which showed a long-term decline in mean clutch size. We can not test these suggestions directly, but our results agree with the above mentioned studies.

The second significant factor was habitat. In our study, mean number of fledged chicks was highest for freshwater habitats. This trend was also found by Frederick et al. (1992) who reported on lower survival of nesting attempts in saline habitats. He also noted fewer aerial and terrestrial predators in freshwater colonies in comparison with estuarine colonies that could alternatively explain this trend.

5. References

Alexander, R., D. (1974) The evolution of social behavior. Annual Review of Ecology and Systematics 5: 325-383.

Aluigi, A., Galli, L. and Spanò, S. (2003) Nuovi dati sulla nidificazione dell'airone cenerio, *Ardea cinerea*, in valle Stura (Genova). Riv. Ital. Orn. 73: 3-8.

Anderson, T., R. (1994) Breeding biology of House Sparrows in Northern Lower Michigan. The Wilson Bulletin 106: 537-548.

Ashkenazi, S. and Yom-Tov, Y. (1997) The breeding biology of the Black-crowned Night heron (*Nycticorax nycticorax*) and the little egret (*Egretta garzetta*) at the Huleh Nature Reserve, Israel. Journal of Zoology 242: 623-641.

Ashmole, N., P. (1963) The regulation of numbers of tropical oceanic birds. Ibis 103: 458-473.

Baker, S., D. and Sepúlveda, M., S. (2009) An evaluation of the effects of persistent environmental contaminants on the reproductive success of the Great Blue Herons (*Ardea herodias*) in Indiana. Ecotoxicology 18: 271-280.

Bartolome, J., Igual, J., M., Sarasa, C., G., Garrido J., R. and Fernández-Cruz M. Factores que influyen en la oriductividad de la garceta común (*Egretta garzetta*) y la garcilla bueyera (*Bubulcus ibis*) en Extremadura (sw de España) manuscript

Baxter, G., S. (1994) The influence of synchronous breeding, natal tree position and rainfall on egret nesting success. Colonial Waterbirds 17: 120-129.

Bennets, R., E., Fasola, M., Hafner, H. and Kayser, Y. (2000) Influence of environmental and density-dependent factors on reproduction of little egrets. The Auk 117: 634-649.

Blus, L., J., Henny, C., J. and Kaiser, E., T. (1980) Pollution ecology of breeding Great Blue Herons in the Columbia Basin, Oregon and Washington. The Murrelet 61: 63-71.

Blus, L., J., Henny, C., J., Anderson, A. and Fitzner R., E. (1985) Reproduction, mortality, and heavy metal concentrations in Great Blue Herons from three colonies in Washington and Idaho. Colonial Waterbirds 8: 110-116.

Blus, L., J., Rattner, B., A., Melancon, M., J. and Henny, C., J. (1997) Reproduction of Black-crowned Night-herons related to predation and contaminants in Oregon and Washington, USA. Colonial Waterbirds 20: 185-197.

Burger, J. (1982) An overview of proximate factors affecting reproductive success in colonial birds: Concluding remarks and summary of panel discussion. Colonial Waterbirds 5: 58-65.

Burkeholder, G. and Smith, D., G. (1991) Nest trees and productivity of Great Blue Herons (*Ardea herodias*) at Knox Lake, north-central Ohio. Colonial Waterbirds 14: 61-62.

Butler, R., W., Whitehead, P., E., Breault, A., M. and Moul, I., E. (1995) Colony effects on fledging success of Great Blue Herons (*Ardea herodias*) in British Columbia. Colonial Waterbirds 18: 159-165.

Carlson, B., A. and McLean, B., E. (1996) Buffer zones and disturbance types as predictors of fledging success in Great Blue Herons, *Ardea herodias*. Colonial Waterbirds 19: 124-127.

Carrillo, J. and Gonzáles-Dávila, E. (2009) Latitudinal variation in breeding parameters of the Common Kestrel *Falco tinnunculus*. Ardeola 56: 215-228.

Cody, M., L. (1966) A general theory of clutch size. Evolution 20: 174-184.

Custer, T.,W., Hensler G., L. and Kaiser, E., T. (1983) Clutch size, reproductive success, and organochlorine contaminants in Atlantic Black-crowned Night-heron. The Auk 100: 699-710.

Donázar, J., A. (1990) Geographic variation in clutch and brood size of Eagle Owl Bubo *bubo* in the Western Palearctic. Journal of Ornithology 131: 439-443.

Dowd, E., M. and Flake, L., D. (1984) Great Blue Heron nesting biology on the James River in South Dakota. Prairie Naturalist 16: 159-166.

Durmuş, A. and Adizel, O. (2010) Breeding ecology of Night Heron (*Nycticorax nycticorax* Linne, 1758) in the Lake van Basin, Turkey. The Journal of Animal & Plant Sciences 20: 73-78.

Edford, L., E. (1976) Breeding biology of the Great Blue Heron. Thesis. The Ohio State University.

Eissinger, A. (2005) Post Point Heron Colony, baseline study annual report 2005. Nahkeeta Northwest Wildlife Services.

Erwin, R., M. and Custer, T., W. (1982) Estimating reproductive success in colonial waterbirds: An evaluation. Colonial Waterbirds 5: 49-56.

Erwin, M., R., Haig, J., G., Stotts, D., B. and Hatfield, J., S. (1996) Reproductive success, growth and survival of Black-crowned Night-heron (*Nycticorax nycticorax*) and Snowy Egret (Egretta thula) chicks in coastal Virginia. The Auk 113: 119-130.

Fernández-Cruz, M. and Campos, F. (1993) The breeding of Grey Herons (*Ardea cinerea*) in Western Spain: The Influence of age. Colonial Waterbirds 16: 53-58.

Findholt, S., L. and Trost, C., H. (1985) Organochlorine pollutants, eggshell thickness, and reproductive success of Black-crowned Night-herons in Idaho, 1979. Colonial Waterbirds 8: 32-41.

Frederick, P., C. and Collopy, M., W. (1989) Nesting success of five ciconiiform species in relation to water conditions in the in the Florida Everglades. The Auk 106: 625-634.

Frederick, P., C., Bjork, R., Bancroft, T., G. and Powell, G., V., N. (1992) Reproductive success of three species of herons relative to habitat in Southern Florida. Colonial Waterbirds 15: 192-201.

Fujioka, M. (1984) Asynchronous hatching, growth and survival of chicks of the Cattle Egret Bubulcus ibis. Tori 33: 1-12.

Gladstone, D., E. (1979) Breeding success of Great Egrets in New Yersey and Mexico. American Midland Naturalist 102: 368-373.

Hanzák, J. (1965) Hnízdní biologie kvakoše nočního (*Nycticorax nycticorax*) na jihočeských koloniích. Sylvia 17: 23-76.

Harris, M., L., Elliot, J., E., Butler, R., W. and Wilson L., K. (2003) Reproductive success and chlorinated hydrocarbon contamination of resident Great Blue Herons (*Ardea herodias*) from coastal British Columbia, Canada, 1977 to 2000. Environmental Pollution 121: 207-227.

Heath, K. and Parkes, M. (2002) Great Captains Island heron and egret study. Audubon, Connecticut.

Henny, C., J., Blus, L., J., Krynitsky, A., J. and Bunck, C., M. (1984) Current impact of DDE on Black-crowned Night-herons in the Intermountain West. The Journal of Wildlife Management 48: 1-13.

Hilaluddin, Shah, J., N. and Shawl, T., A. (2003) Nest site selection and breeding success by Cattle Egret and Little Egret in Amroha, Uttar Pradesh, India. Waterbirds 26: 444-448.

Hill, E., F. and Henny, C., J. (2008) Mercury and drought along the lower Carson River, Nevada: II. Snowy Egret and Black-crowned Night-heron reproduction on Lahontan Reservoir, 1997-2006. Ecotoxicology 17: 117-131.

Hockey, P., A., R. and Wilson, W., A. (2003) Reproductive traits of marine terns (Sternidae): Evidence for food limitation in the tropics? Ostrich 74: 110-116.

Hothem, R., L. and Hatch, D. (2004) Reproductive success of the Black-crowned Night-heron at Alcatraz Island, San Francisco Bay, California, 1990-2002. Waterbirds 27: 112-125.

Chatwin, T., Bonar, S. and Kissinger, M. (2007) Pacific Great Blue Heron population and monitoring, Vancouver Island and Gulf Islands 2005. Wildlife Working Report No. WR 110.

Inoue, Y. (1985) The process of asynchronous hatching and sibling competition in the Little Egret Egretta garzetta. Colonial Waterbirds 8: 1-12.

Jakubas, D. (2005) Factors affecting the breeding success of Grey Heron (Ardea cinerea) in northern Poland. Journal of Ornithology 146: 27-33.

Jenni, D., A. (1969) A study of the ecology of four species of herons during the breeding season at Lake Alice, Alaucha County, Florida. Ecological Monographs 39: 245-270.

Kazantzidis, S., Gounter, V., Pyrovetsi, M. and Sinis, A. (1997) Comparative nest site selection and breeding success in 2 sympatric Ardeids, Black-crowned Night-heron (*Nycticorax nycticorax*) and Little Egret (*Egretta garzetta*) in the Axios Delta, Macedonia, Greece. Colonial Waterbirds 20: 505-517.

Keithmaleesatti, S., Thirakhupt, K., Pradatsudarasar, A., Varanusupakul, P., Kitana, N. and Robson, M. (2006) Concentration of organochlorine in egg yolk and reproductive success of *Egretta garzetta* (Linnaeus, 1758) at Wat Tan-en non-hunting area, Phra Nakhorn Si Ayuthaya Province, Thailand. Ecotoxicology and Environmental Safety 68: 79-83.

Kelly, J., P., Etienne, K., Strong, C., McCaustland, M. and Parkes, M., L. (2007) Status, trends, and implications for the conservation of heron and egret nesting colonies in the San Francisco Bay area. Waterbirds 30: 455-478.

Kelly, J., P., Pratt, H., M. and Greene, P., L. (1993) The distribution, reproductive success, and habitat characteristics of heron and egret breeding colonies in the San Francisco Bay area. Colonial Waterbirds 16: 18-27.

Kim, J. and Koo, T. (2009) Nest site characteristic and reproductive parameters of Grey Herons *Ardea cinerea* in Korea. Zoological Studies 48: 657-664.

Koenig, W., D. (1984) Geographic variation in clutch size in the Northern Flicker (*Colaptes auratus*): Support for Ashmole´s hypothesis. The Auk 101: 698-706.

Kopij, G. (1999) Breeding success in the Cattle Egret in relation to clutch size. South African Journal of Wildlife Research 29: 112.

Krebs, E., A., Hunte, W. and Green, D., J. (2004) Plume variation, breeding performance and extra pair copulations in the Cattle Egret. Behaviour 141: 479-499.

Kushlan, J., A. (1993) Colonial waterbirds as bioindicators of environmental change. Colonial Waterbirds 16: 223-251.

Kushlan, J., A. and Hancock, J., A. (2005) Bird families of the world – The Herons. Oxford University Press.

Maddock, M. and Baxter, G., S. (1991) Breeding success of egrets related to rainfall: a six-year Australian study. Colonial Waterbirds 14: 133-139.

Maxwell II, G., R. and Kale II, H., W. (1977) Breeding biology of five species of herons in coastal Florida. The Auk 94: 689-700.

McClaren, E., L. (2003) Pacific Great Blue Heron Population Inventory and Monitoring Project 2003, Strait of Georgia, British Columbia. Ministry of Water, Land and Air Protection, Nanaimo, BC.

McKilligan, N., G. (1985) The breeding success of the Indian Cattle Egret *Ardeola ibis* in eastern Australia. Ibis 127: 530-536.

McKilligan, N., G. (1997) A long term study od factors influencing the breeding success of the Cattle Egret in Australia. Colonial Waterbirds 20: 419-428.

Meanley, B. (1955) A nesting study of the Little Blue Heron in Eastern Arkansas. The Wilson Bulletin 67: 84-99.

Milstein, P. le S., Prestt I. and Bell, A., A. (1970) The breeding cycle of the Grey Heron. Ardea 58: 171-257.

Mora, M., M. (1991) Organochlorines and breeding success in Cattle Egrets from the Mexicali Valley, Baja California, Mexico. Colonial Waterbirds 14: 127-132.

Naylord, B., Simard, J., Alkins, M., Lucking, G. and Watt, B. (2003) Efects of forest management practices on breeding Ospreys and Great Blue Herons in the Boreal and Great Lakes – St. Lawrence forests of Ontario: Final Report Draft 2.

Olmos, F. and Silva e Silva, R. (2002) Breeding biology of the Little Blue Heron (*Egretta caeruela*) in southeastern Brazil. Ornitologia Neotropical 13: 17-30.

Parejo, D., Sánchez-Guzmán, J., M. and Avilés, J., M. (2001) Breeding biology of the Cattle Egret *Bubulcus ibis* in the southwest Spain. Bird Study 48: 367-372.

Parsons, K., C. (1995) Heron nesting at Pea Patch Island, upper Delaware Bay, USA: abundance and reproductive success. Colonial Waterbirds 18: 69-78.

Parsons, K., C. (2003) Reproductive success of wading birds using *Phragmites* marsh and upland nesting habitats. Estuaries 26: 596-601.

Parsons, K., C. and McColpin, A., C. (1995) Great Blue Heron reproductive success in upper Delaware Bay. Journal of Field Ornithology 66: 184-191.

Parsons, K., C., Schmidt, S., R. and Matz, A., C. (2001) Regional patterns of wading bird productivity in northeast U.S. estuaries. Waterbirds 24: 323-330.

Payne, R., B. (1976) The clutch size and numbers of eggs of Brown-headed Cowbirds: effects of latitude and breeding season. The Condor 78: 337-342.

Petry, M., V. and Da Silva Fonseca, V., S. (2005) Breeding success of colonist species *Bubulcus ibis* (Linnaeus, 1758) and four native species. Acta Zoologica 86: 217-221.

Pietrelli, L. and Biondi, M. (2009) Notes on Little Egret breeding biology and on mercury content in egg shells and feathers. Rendiconti Lincei 20: 219-224.

Porkert, J. and Zajíc, J. (2005) The breeding biology of the Common Redstart, *Phoenicurus phoenicurus*, in the Central European pine forest. Folia Zoologica 54: 111-122.

Potyraj, J., J and Creighton, P., D. (1977) Breeding success and nestling growth of the Cattle Egret (*Bubulcus ibis*). Proceedings Colonial Waterbirds Group, Northern Illinois University.

Pratt, H., M. (1974) Breeding of Great Blue Herons and Great Egrets at Audubon Canyon ranch, California, 1972-1973. Western Birds 5:127-136.

Pratt, H., M. and Winkler, D., W. (1985) Clutch size, timing of laying, and reproductive success in a colony of Great Blue Herons and Great Egrets. The Auk 102: 49-63.

Quinney, T., E. (1982) Growth, diet and mortality of nestling Great Blue Heron. The Wilson Bulletin 94: 571-577.

Ranglack, G., S., Angus, R., A. and Marion, K., R. (1991) Physical and temporal factors influencing breeding success of Cattle Egrets (*Bubulcus ibis*) in a west Alabama colony. Colonial Waterbirds 14: 140-149.

Rattner, B., A., McGowan, P., C., Hatfield, J., S., Hong, C., -S. and Chu, S., G. (2001) Organochlorine contaminant exposure and reproductive success of Black-crowned Night-herons (*Nycticorax nycticorax*) nesting in Baltimore Harbor, Maryland. Archives of Environmental Contamination and Toxicology 41: 73-82.

Ricklefs, R., E. (1969) An analysis of nesting mortality in birds. Smithsonian Contributions to Zoology 9: 1-48.

Rodgers, J., A., Jr. (1978) Breeding behavior of the Luisiana Heron. The Wilson Bulletin 90: 45-59.

Rodgers, J., A., Jr. (1986) Additional observations on the reproductive success of herons on the west coast of Florida. Florida Field Naturalist 14: 77-79.

Rodgers, J., A., Jr. (1987) Breeding chronology and reproductive success of Cattle Egrets and Little Blue Herons on the west coast of Florida, USA. Colonial Waterbirds 10: 38-44.

Rubolini, D. and Fasola, M. (2008) Geographic patterns in reproductive parameters among Nearctic herons (Ardeidae). The Auk 125: 374-383.

Rumbold, D., G., Niemczyk, S., L., Fink, L., E., Chandrasekhar, T, Harkanson, B. and Laine, K., A. (2001) Mercury in eggs and feathers of Great Egrets (*Ardea albus*) from the Florida Everglades. Archives of Environmental Contamination and Toxicology 41: 501-507.

Si Bachir, A., Barbraud. C., Doumandji, S. and Hafner, H. (2008) Nest site selection and breeding success in an expanding species, the Cattle Egret *Bubulcus ibis*. Ardea 96: 99-107.

Skutch, A., F. (1949) Do tropical birds rear as many young as they can nourish? Ibis 91: 430-455.

Smith, J., P. and Collopy, M., W. (1995). Colony turnover, nest success and productivity, and causes of nest failure among wading birds (Ciconiiformes) at Lake Okeechobee, Florida (1989-1992). Archiv für Hydrobiologie. Special Issues. Advances in Limnology 45: 287-316

Spahn, S., A. and Sherry, T., W. (1999) Cadmium and lead exposure associated with reduced growth rates, poorer fledging success of Little Blue Heron chicks (*Egretta caerulea*) in South Lousiana Wetlands. Archives of Environmental Contamination and Toxicology 37: 377-384.

Stabins, A., J., Raedeke, K., J. and Manuwal, D., A. (2006) Productivity of Great Blue Herons in King County, Washington. Northwest Science 80: 116-119.

Styrsky, J., N., Brawn, J., D. and Robinson, S., K. (2005) Juvenile mortality with clutch size in a Neotropical bird. Ecology 86: 3238-3244.

StatSoft, Inc. (2008) STATISTICA (data analysis software system), version 8.0. www.statsoft.com.

Sullivan, J., P. (1988) Effects of provisioning rates and number fledged on nestling aggression in Great Blue Herons. Colonial Waterbirds 11: 220-226.

Teal, J., M. (1965) Nesting success of egrets and herons in Georgia. The Wilson Bulletin 77: 257-263.

Telfair, R., C., II, and Bister, T., J. (2004) Long-term breeding success of the Cattle Egret in Texas. Waterbirds 27: 69-78.

Telfair, R., C., II, McCrimmon, Jr., D., A. and Fryska, S., T. (2000) Population dynamics od the Cattle Egret in Texas, 1954-1999. Waterbirds 23: 187-195.

Thomas, C., M. and Anthony, R., G. (1999) Environmental contaminants in Great Blue Herons (*Ardea herodias*) from the Lower Columbia and Willamette Rivers, Oregon and Washington, USA. Environmental Toxicology and Chemistry 18: 2804-2816.

Thomas, F., Kayser, Y. and Hafner, H. (1999) Nestling size rank in the Little Egret (*Egretta garzetta*) influences subsequent breeding success of offspring. Behavioral Ecology and Sociobiology 45: 466-470.

Tiller, B., L., Marco, J., D. and Rickard, W., H. (2005) Metal concentrations, foraging distances, and fledging success of Great Blue Herons nesting along the hanford reach of the Columbia River. Environmental Monitoring and Assessment 104: 71-79.

Tremblay, J. and Ellison, L., N. (1980) Breeding success of the Black-crowned Night-Heron in the St. Lawrence Estuary. Canadian Journal of Zoology 58: 1259-1263.

Uzun, A. (2009) Do the height and location of Black-crowned Night-heron (*Nycticorax nycticorax*) nests affect egg production and breeding success? Waterbirds 32: 357-359.

Uzun, A. and Kopij, G. (2010) Effect of the colony edge on the clutch size and fledging success in the Little Egret *Egretta garzetta* (L.). Polish Journal of Ecology 58: 393-396.

van Vessem, J. and Draulans, D. (1986) The adaptive significance of colonial breeding in the Grey Heron *Ardea cinerea*: inter- and intra-colony variability in breeding success. Ornis Scandinavica 17: 356-362.

Wainwright, S., E., Mora, M., A., Sericano, J., L. and Thomas, P. (2001) Chlorinated hydrocarbons and biomarkers of exposure in wading birds and fish of the lower Rio Grande Valley, Texas. Archives of Environmental Contamination and Toxicology 40: 101-111.

Ward, P. and Zahavi, A. (1973) The importace of certain assemblages of birds as "information-centres" for food-finding. Ibis 115: 517-534.

Werschkul, D., McMahon, E., Leitschuh, M., English, S., Skibinski, C. and Williamson, G. (1977) Observations on the reproductive ecology of the Great Blue Heron (*Ardea herodias*) in Western Oregon. The Murrelet 58: 7-12.

Wiese, J., H. (1977) Large scale mortality of nestling Ardeids caused by Nematode infection. Journal of Wildlife Diseases 13: 376-382.

Witt, J., W. (2006) Great Blue Heron productivity at Mason Neck National Wildlife Refuge in northern Virginia, and the potential impacts of weather during a 13-year interval. Waterbirds 29: 345-359.

Wong, L., C. and Kwok, H., K. (2001) Egretry counts in Hong Kong, with particular reference to the Mai Po inner deep bay Ramsar site. Bird Watching Society, Hong Kong. Summer report.

Young, B., E. (1994) Geographic and seasonal patterns of clutch-size variation in House Wrens. The Auk 111: 545-55

6. Appendix

List of the mean fledged chicks data, sorted according to species and start year of the study. N – number of studied nests. Habitat types:

F = freshwater, S = saltwater, E = estuarine.

Species	Start year	Mean fledged offspring	N	Country	Latitude	Longtitude	Habitat	Reference
Black-crowned Night-heron	1958	2.13	8	USA	31.00 N	81.00 W	F	Teal 1965
	1959	2.56	38	Czech Republic	49.30 N	14.42 E	F	Hanzák 1965
	1975	2.32	198	USA	42.00 N	71.00 W	S	Custer et al. 1983
	1975	0.99	122	USA	37.00 N	76.00 W	S	Custer et al. 1983
	1977	1.15	521	Israel	35.05 N	35.36 E	F	Ashkenazi and Yom-Tov 1997
	1978	2.21	96	USA	45.00 N	119.00 W	F	Henny et al. 1984
	1979	2.30	11	USA	28.00 N	83.00 W	S	Rodgers 1986
	1979	2.25	165	USA	42.00 N	71.00 W	E	Custer et al. 1983
	1979	1.91	31	USA	37.00 N	76.00 W	S	Custer et al. 1983
	1979	2.07	31	USA	41.30 N	71.00 W	E	Custer et al. 1983
	1979	1.10	63	USA	42.56 N	111.37 W	F	Findholt and Trost 1979
	1979	1.30	118	USA	43.53 N	112.23 W	F	Findholt and Trost 1979
	1979	2.41	103	USA	42.39 N	113.27 W	F	Findholt and Trost 1979
	1986	2.32	217	USA	40.60 N	74.17 W	S	Parsons et al. 2001
	1986	1.82	65	USA	39.58 N	75.57 W	S	Parsons et al. 2001
	1986	2.80	92	USA	42.25 N	70.87 W	S	Parsons et al. 2001
	1986	2.46	143	USA	41.62 N	70.42 W	S	Parsons et al. 2001
	1990	2.03	485	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	1.54	347	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	1.51	284	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	0.74	2187	USA	37.49 N	122.25 W	S	Hothem and Hatch 2004
	1991	0.39	15	USA	46.05 N	118.55 W	F	Blus et al. 1997
	1991	2.86	58	USA	45.55 N	119.37 W	F	Blus et al. 1997
	1991	0.94	33	USA	47.03 N	119.23 W	F	Blus et al. 1997
	1991	1.47	44	USA	45.50 N	119.59 W	F	Blus et al. 1997
	1991	1.87	35	USA	38.00 N	122.00 W	S	Kelly et al. 1993
	1991	2.20	58	USA	46.05 N	118.57 W	F	Blus et al. 1997
	1992	2.40	59	USA	37.56 N	75.25 W	F	Erwin et al. 1996

	Year	Value	N	Location	Latitude	Longitude	Type	Reference
	1996	1.83	40	Spain	38.53 N	6.58 W	F	Parejo et al. 2001
	1998	1.55	69	USA	39.21 N	76.52 W	E	Rattner et al. 2001
	1998	2.48	362	Greece	40.20 N	22.53 E	F	Kazantzidis et al. 1997
	1998	1.36	183	Brazil	29.34 N	51.15 W	F	Petry and Da Silva Fonseca 2005
	2001	1.40	5	China	22.00 N	114.00 E	S	Wong and Kwok 2001
	2001	1.50	14	China	22.00 N	114.00 E	S	Wong and Kwok 2001
	2002	1.90	16	USA	41.00 N	73.00 W	S	Heath and Parkes 2002
	2006	3.14	1364	Turkey	38.24 N	42.55 E	F	Durmus and Adizel 2010
	2007	2.61	100	Turkey	40.50 N	30.28 E	F	Uzun 2009
Cattle Egret	1954	2.55	(-)	USA	30.00 N	95.00 W	F	Telfair et al. 2000
	1960	2.87	73	USA	48.00 N	99.00 W	F	Jenni 1969
	1973	2.46	31	USA	27.38 N	80.22 W	S	Maxwell and Kale 1977
	1974	2.56	2279	Texas	32.00 N	96.00 W	F	Telfair II and Bister 2004
	1974	2.83	4363	Texas	32.00 N	96.00 W	F	Telfair II and Bister 2004
	1976	1.49	(-)	USA	34.00 N	81.00 W	F	Potyraj and Creighton (-)
	1978	3.00	38	Japan	34.50 N	136.35 E	F	Fujioka 1984
	1979	1.30	211	USA	28.00 N	83.00 W	S	Rodgers 1987
	1982	2.46	543	Australia	32.43 S	151.38 E	F	Maddock 1991
	1985	0.66	930	USA	32.00 N	87.00 W	F	Ranglack et al. 1991
	1986	1.83	409	Australia	32.40 S	151.43 E	F	Baxter 1994
	1986	2.21	453	Australia	27.31 S	152.20 E	F	McKilligan 1997
	1986	1.49	98	USA	39.58 N	75.57 W	E	Parsons et al. 2001
	1986	1.97	88	USA	40.60 N	74.17 W	E	Parsons et al. 2001
	1987	1.50	1016	Mexico	32.15 N	115.08 W	F	Mora 1991
	1988	2.99	273	Spain	39.20 N	0.20 W	F	Prosper and Hafner 1996
	1990	0.92	64	Barbados	13.01 N	59.35 W	S	Krebs 2004
	1991	1.91	224	Spain	39.14 N	5.36 E	F	Bartolome et al. (-)
	1993	0.50	266	USA	39.35 N	75.34 W	S	Parsons 2003
	1993	0.93	258	South Africa	27.00 S	27.00 E	F	Kopij 1999
	1996	1.90	213	Spain	38.55 N	6.23 W	F	Parejo et al. 2001
	1996	1.70	235	Spain	39.03 N	6.41 W	F	Parejo et al. 2001
	1996	1.95	236	Spain	38.53 N	6.58 W	F	Parejo et al. 2001
	1997	1.85	210	Algeria	36.41 N	4.51 E	F	Si Bachir 2008
	1998	1.08	2104	Brazil	29.34 S	51.15 W	F	Petry and Da Silva Fonseca 2005
	2001	1.93	29	India	28.76 N	78.22 E	F	Hilaluddin 2003
Great Blue Heron	1967	1.60	365	USA	37.00 N	122.00 W	S	Pratt 1974
	1967	2.20	196	USA	37.56 N	122.41 W	S	Pratt and Winkler 1985
	1974	2.53	88	USA	44.00 N	124.00 W	F	Werschkul et al. 1977
	1974	2.18	97	USA	43.00 N	124.00 W	F	Werschkul et al. 1977

1974	2.20	33	USA	46.00 N	124.00 W	F	Werschkul et al. 1977
1974	2.70	161	USA	46.00 N	124.00 W	S	Werschkul et al. 1977
1974	2.58	86	USA	43.00 N	124.00 W	F	Werschkul et al. 1977
1975	1.93	17	USA	42.00 N	81.00 W	F	Edford 1976
1975	2.27	133	USA	42.00 N	81.00 W	F	Edford 1976
1977	1.65	322	Canada	49.00 N	123.00 W	S	Harris et al. 2003
1977	2.85	28	Canada	45.08 N	65.16 W	S	Quinney 1982
1977	1.16	172	Canada	49.00 N	123.00 W	S	Harris et al. 2003
1978	1.98	25	USA	46.00 N	119.00 W	F	Blus et al. 1980
1979	2.20	158	USA	40.30 N	82.30 W	F	Burkholder and Smith 1991
1981	1.76	84	USA	39.00 N	77.00 W	F	Blus et al. 1985
1984	2.71	50	USA	41.52 N	111.52 W	F	Sullivan 1988
1986	1.51	272	Canada	49.00 N	124.00 W	S	Harris et al. 2003
1986	1.80	58	Canada	49.00 N	123.00 W	S	Harris et al. 2003
1987	2.40	567	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.20	26	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.00	76	Canada	49.00 N	124.00 W	F	Butler et al. 1995
1987	1.20	33	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.40	146	Canada	49.00 N	123.00 W	S	Butler et al. 1995
1987	2.60	121	Canada	50.00 N	124.00 W	S	Butler et al. 1995
1987	1.70	53	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.60	32	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.40	33	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	0.40	6	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.80	140	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.50	2	Canada	49.00 N	124.00 W	F	Butler et al. 1995
1987	0.50	(-)	Canada	50.00 N	124.00 W	E	Butler et al. 1995
1987	0.70	33	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.90	71	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	0.90	21	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.20	112	Canada	49.00 N	123.00 W	S	Butler et al. 1995
1987	1.00	(-)	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.00	(-)	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	0.80	109	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.30	108	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.00	112	Canada	49.00 N	124.00 W	S	Butler et al. 1995

1987	1.50	111	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.70	110	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.10	1511	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	3.00	19	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	1.30	19	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	2.10	107	Canada	49.00 N	124.00 W	F	Butler et al. 1995
1987	0.00	(-)	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	4.00	2	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1987	0.80	51	Canada	49.00 N	124.00 W	S	Butler et al. 1995
1988	1.21	26	Canada	50.00 N	125.00 W	S	Harris et al. 2003
1989	1.71	101	USA	27.33 N	80.67 W	F	Smith and Collopy 1995
1989	2.27	27	Canada	49.00 N	124.00 W	F	Harris et al. 2003
1989	2.36	50	Canada	50.00 N	125.00 W	S	Harris et al. 2003
1989	1.27	20	Canada	49.00 N	124.00 W	F	Harris et al. 2003
1989	1.50	4	Canada	49.00 N	124.00 W	F	Harris et al. 2003
1989	2.36	47	Canada	49.00 N	123.00 W	S	Harris et al. 2003
1989	1.33	15	Canada	49.00 N	124.00 W	S	Harris et al. 2003
1990	1.00	18	Canada	50.00 N	125.00 W	S	Harris et al. 2003
1990	2.01	224	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	1.99	247	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	3.50	8	Canada	49.00 N	124.00 W	S	Harris et al. 2003
1990	2.38	275	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	1.99	15	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	2.06	631	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	2.01	437	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1990	1.82	423	USA	37.30 N	122.00 W	S	Kelly et al. 2007
1991	1.64	13	Canada	49.00 N	123.00 W	S	Harris et al. 2003
1991	1.93	119	USA	38.00 N	122.00 W	S	Kelly et al. 1993
1992	1.57	2232	USA	39.00 N	77.00 W	F	Witt 2006
1992	1.37	164	Canada	49.00 N	124.00 W	S	Harris et al. 2003
1993	1.60	19	USA	39.35 N	75.34 W	S	Parsons and McColpin 1995
1993	2.54	74	USA	41.15 N	82.11 W	F	Carlson and McLean 1996
1993	1.23	46	USA	41.25 N	81.21 W	F	Carlson and McLean 1996
1993	2.45	101	USA	41.17 N	81.22 W	F	Carlson and McLean 1996
1993	1.60	5	USA	41.12 N	81.50 W	F	Carlson and McLean 1996
1993	1.50	26	USA	41.12 N	81.41 W	F	Carlson and McLean 1996

1993	2.21	54	USA	41.18 N	82.20 W	F	Carlson and McLean 1996
1993	2.60	5	USA	41.23 N	80.56 W	F	Carlson and McLean 1996
1993	2.22	81	USA	41.19 N	81.36 W	F	Carlson and McLean 1996
1993	2.50	31	USA	41.90 N	81.33 W	F	Carlson and McLean 1996
1993	2.11	11	USA	41.36 N	81.10 W	F	Carlson and McLean 1996
1993	2.30	246	USA	41.46 N	80.42 W	F	Carlson and McLean 1996
1993	2.50	5	USA	41.80 N	81.18 W	F	Carlson and McLean 1996
1993	2.17	169	USA	41.23 N	80.24 W	F	Carlson and McLean 1996
1993	2.50	39	USA	41.90 N	81.34 W	F	Carlson and McLean 1996
1993	2.17	44	USA	40.45 N	80.13 W	F	Carlson and McLean 1996
1993	2.22	178	USA	41.15 N	81.56 W	F	Carlson and McLean 1996
1993	2.06	38	USA	41.00 N	81.56 W	F	Carlson and McLean 1996
1993	2.28	185	USA	41.30 N	81.17 W	F	Carlson and McLean 1996
1993	2.13	23	USA	40.58 N	81.10 W	F	Carlson and McLean 1996
1994	2.30	76	USA	46.00 N	123.00 W	F	Thomas and Anthony 1999
1994	2.05	88	USA	46.00 N	123.00 W	F	Thomas and Anthony 1999
1994	2.10	75	USA	46.00 N	123.00 W	F	Thomas and Anthony 1999
1994	2.05	99	USA	48.00 N	122.00 W	E	Thomas and Anthony 1999
1994	2.25	89	USA	46.00 N	123.00 W	F	Thomas and Anthony 1999
1994	2.35	95	USA	46.00 N	123.00 W	F	Thomas and Anthony 1999
1996	2.60	34	USA	47.00 N	119.00 W	F	Tiller et al. 2005
1996	0.33	3	USA	47.00 N	119.00 W	F	Tiller et al. 2005
1996	3.00	6	USA	47.00 N	119.00 W	F	Tiller et al. 2005
2000	2.16	37	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	1.66	102	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	3.00	17	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	1.80	15	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	2.00	50	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	1.27	11	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	0.00	9	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	2.11	67	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	1.33	3	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	1.81	21	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	0.00	17	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	3.00	1	USA	47.00 N	122.00 W	E	Stabins et al. 2006
2000	0.00	4	USA	47.00 N	122.00 W	E	Stabins et al. 2006

2001	2.40	1080	Canada	52.00 N	85.00 W	F	Naylor et al. 2003
2003	0.70	19	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.00	4	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	3	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	1.00	1	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	38	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	1.00	1	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.33	3	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	1.42	53	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	9	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.50	4	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	1	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.20	5	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	1.25	4	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	1	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	10	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	3	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.55	22	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	20	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.67	3	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	2.67	3	Canada	49.00 N	124.00 W	E	McClaren 2003
2003	0.00	15	Canada	49.00 N	124.00 W	E	McClaren 2003
2005	1.31	160	USA	40.24 N	87.00 W	F	Baker and Sepúlveda 2009
2005	1.42	60	USA	42.16 N	86.52 W	F	Baker and Sepúlveda 2009
2005	1,11	134	USA	40.24 N	86.44 W	F	Baker and Sepúlveda 2009
2005	2,60	64	USA	41.33 N	87.26 W	F	Baker and Sepúlveda 2009
2005	1,36	98	USA	41.16 N	87.90 W	F	Baker and Sepúlveda 2009
2005	1,97	63	USA	39.16 N	86.15 W	F	Baker and Sepúlveda 2009
2005	2.00	1	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	1,47	30	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	0,00	2	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	0,00	11	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	0,00	5	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	3,50	5	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
2005	1,00	18	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007

	2005	0,00	11	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
	2005	1,33	6	Canada	49.00 N	124.00 W	E	Chatwin et al. 2007
Great Egret	1958	1.02	43	USA	31.00 N	81.00 W	F	Teal 1965
	1967	1.19	595	USA	37.00 N	122.00 W	S	Pratt 1974
	1967	2.05	319	USA	37.56 N	122.41 W	S	Pratt and Winkler 1985
	1973	1.88	13	USA	27.38 N	80.22 W	S	Maxwell and Kale 1977
	1975	2.48	27	Mexico	21.30 N	105.17' W	S	Gladstone 1979
	1975	1.71	21	USA	39.25 N	74.25 W	S	Gladstone 1979
	1982	2.14	183	Australia	32.53 S	151.42 E	F	Maddock 1991
	1986	1.69	120	Australia	32.40 S	151.43 E	F	Baxter 1994
	1986	1.88	445	USA	25.00 N	81.00 W	F	Frederick and Collopy 1989
	1989	1.90	324	USA	27.33 N	80.67 W	F	Smith and Collopy 1995
	1990	2.27	1733	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.93	13	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	1.82	513	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.04	1007	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.23	210	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.04	350	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1991	2.04	6	USA	38.00 N	122.00 W	S	Kelly et al. 2007
	1997	2.93	17	USA	26.65 N	99.20 W	F	Wainwright et al. 2001
	1999	1.93	27	USA	26.06 N	80.63 W	F	Rumbold et al. 2001
	2001	1.90	10	China	22.00 N	114.00 E	S	Wong and Kwok 2001
	2002	1.00	5	USA	41.00 N	73.00 W	S	Heath and Parkes 2002
Grey heron	1967	2.30	12	Great Britain	53.13 N	0.11 E	F	Milstein et al. 1970
	1973	2.60	224	Spain	40.09 N	6.33 W	F	Fernandez-Cruz and Campos 1993
	1981	3.50	61	Belgium	51.00 N	5.00 E	F	van Vessem and Draulans 1986
	1981	2.50	15	Belgium	51.00 N	5.00 E	F	van Vessem and Draulans 1986
	1981	3.10	10	Belgium	51.00 N	5.00 E	F	van Vessem and Draulans 1986
	1981	3.70	8	Belgium	51.00 N	5.00 E	F	van Vessem and Draulans 1986
	1981	2.50	2	Belgium	51.00 N	4.00 E	F	van Vessem and Draulans 1986
	1981	3.00	1	Belgium	51.00 N	4.30 E	F	van Vessem and Draulans 1986
	1981	4.00	1	Belgium	51.00 N	4.00 E	F	van Vessem and Draulans 1986
	1981	2.70	53	Belgium	51.00 N	4.00 E	F	van Vessem and Draulans 1986
	1981	2.00	5	Belgium	51.00 N	3.30 E	F	van Vessem and Draulans 1986
	1981	1.70	48	Belgium	51.00 N	4.00 E	F	van Vessem and Draulans 1986
	1981	3.40	13	Belgium	51.00 N	5.00 E	F	van Vessem and Draulans 1986

	Year			Country	Latitude	Longitude		Reference
	1988	3.56	105	Spain	39.20 N	0.20 W	F	Prosper and Hafner 1996
	2000	2.07	88	Korea	37.02 N	127.02 E	F	Kim and Koo 2009
	2000	2.80	36	Poland	58.37 N	18.37 E	S	Jakubas 2004
	2000	3.20	78	Poland	54.21 N	19.14 E	S	Jakubas 2004
	2000	2.50	60	Poland	53.57 N	19.28 E	S	Jakubas 2004
	2003	2.11	(-)	Italy	44.31 N	8.41 E	F	Aluigi et al. 2003
Little Blue Heron	1952	2.95	40	USA	34.25 N	91.65 W	F	Menley 1955
	1954	3.07	30	USA	34.22 N	91.70 W	F	Meanley 1955
	1960	2.30	52	USA	48.00 N	99.00 W	F	Jenni 1969
	1973	2.05	21	USA	27.38 N	80.22 W	S	Maxwell and Kale 1977
	1976	1.49	146	USA	28.00 N	83.00 W	S	Rodgers 1980
	1979	1.60	341	USA	28.00 N	83.00 W	S	Rodgers 1987
	1986	2.15	20	USA	25.83 N	80.67 W	S	Frederick et al. 1992
	1986	2.58	94	USA	25.83 N	80.67 W	F	Frederick et al. 1992
	1986	2.55	162	USA	25.00 N	81.00 W	F	Frederick and Collopy 1989
	1989	2.20	55	USA	27.33 N	80.67 W	F	Smith and Collopy 1995
	1993	2.25	48	USA	39.35 N	75.34 W	S	Parsons 1995
	1993	0.94	72	USA	39.35 N	75.34 W	S	Parsons 2003
	1995	2.75	41	USA	30.00 N	91.00 W	F	Spahn and Sherry 1999
	1995	3.77	37	USA	30.00 N	91.00 W	F	Spahn and Sherry 1999
	1996	0.67	58	Brazil	23.52 S	46.21 W	E	Olmos and Silva e Silva 2002
	1997	0.94	140	Brazil	23.55 S	46.20 W	E	Olmos and Silva e Silva 2002
Little Egret	1970	0.86	2092	France	43.00 N	4.00 E	S	Bennetts et al. 2000
	1977	1.71	277	Israel	35.05 N	35.36 E	F	Ashkenazi and Yom-Tov 1998
	1977	2.09	37	Japan	34.50 N	135.35 E	F	Inoue 1985
	1982	2.09	79	Australia	32.53 N	151.42 E	F	Maddock 1991
	1982	2.93	56	France	44.00 N	6.00 E	F	Thomas et al. 1999
	1986	1.70	61	Australia	32.40 N	151.43 E	F	Baxter 1994
	1988	3.47	211	Spain	39.20 N	0.20 W	F	Prosper and Hafner 1996
	1992	1.06	112	Spain	39.14 N	5.36 E	F	Bartolome et al. (-)
	1996	2.35	33	Spain	38.53 N	6.58 W	F	Parejo et al. 2001
	1996	2.25	21	Spain	38.55 N	6.23 W	F	Parejo et al. 2001
	1996	1.95	14	Spain	39.03 N	6.41 W	F	Parejo et al. 2001
	1998	2.43	648	Greece	40.20 N	22.53 E	F	Kazantzidis et al. 1997
	2001	1.74	23	India	28.76 N	78.22 E	F	Hilaluddin 2003
	2001	1.60	7	China	22.00 N	114.00 E	S	Wong and Kwok 2001

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	2001	2.10	19	China	22.00 N	114.00 E	S	Wong and Kwok 2001
	2002	0.69	36	Thailand	14.31 N	100.24 E	F	Keithmaleesatti et al. 2006
	2008	2.47	100	Turkey	40.50 N	30.28 E	F	Uzun and Kopij 2010
Snowy Egret	1958	0.80	30	USA	31.00 N	81.00 W	F	Teal 1965
	1960	1.84	91	USA	48.00 N	99.00 W	F	Jenni 1969
	1973	1.67	77	USA	27.38 N	80.22 W	S	Maxwell and Kale 1977
	1976	0.39	126	USA	39.35 N	74.34 W	S	Wiese 1977
	1979	1.76	42	USA	28.00 N	83.00 W	S	Rodgers 1986
	1986	2.45	31	USA	25.83 N	80.67 W	F	Frederick et al. 1992
	1986	2.15	44	USA	25.83 N	80.67 W	S	Frederick et al. 1992
	1986	2.71	52	USA	42.25 N	70.87 W	S	Parsons et al. 2001
	1986	2.39	127	USA	40.60 N	74.17 W	S	Parsons et al. 2001
	1986	1.64	53	USA	39.58 N	75.57 W	S	Parsons et al. 2001
	1986	2.71	103	USA	41.62 N	70.42 W	S	Parsons et al. 2001
	1986	2.78	15	USA	25.00 N	81.00 W	F	Frederick and Collopy 1989
	1989	2.01	206	USA	27.33 N	80.67 W	F	Smith and Collopy 1995
	1990	1.82	38	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.18	35	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.37	97	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1990	2.49	160	USA	37.30 N	122.00 W	S	Kelly et al. 2007
	1991	2.19	14	USA	38.00 N	122.00 W	S	Kelly et al. 2007
	1992	2.16	70	USA	37.56 N	75.25 W	F	Erwin et al. 1996
	1993	1.60	36	USA	39.35 N	75.34 W	S	Parsons 1995
	1993	0.48	128	USA	39.35 N	75.34 W	S	Parsons 2003
	1997	1.09	96	USA	39.00 N	119.00 W	F	Hill and Henny 2008
	1998	1.10	139	Brazil	29.34 S	51.15 W	F	Petry and Da Silva Fonseca 2005
	2002	2.75	4	USA	41.00 N	73.00 W	S	Heath and Parkes 2002