

DO VITAMINS A AND E HAVE AN IMPACT ON THE FERTILITY OF HUMBOLDT PENGUINS

Spheniscus humboldti?

by Kelly Rose and Caitlyn Hopkins

Aims of study

To investigate the impact on fertility from adding supplementary vitamins A (retinol) and E (α -tocopherol) to the diet of captive Humboldt Penguins.

To improve the number of viable chicks produced each year.

Introduction

Humboldt Penguin in the wild

The Humboldt Penguin *Spheniscus humboldti* is native to the coastlines of Peru and Chile in South America. The birds spend time at their colonies nesting, rearing their chicks and moulting, but otherwise are thought to spend most of the year at sea. The species is listed as CITES 1, due mostly to extensive guano mining in the nineteenth and twentieth centuries, for use as a commercial fertiliser. The continuous disturbance of the birds at their nesting grounds in the course of its collection reduced the population size considerably (del Hoyo et al. 1993). Other problems such as intensive egg collection, indiscriminate fishing and oil spills (Frost et al. 1976) have also contributed to the reduction in numbers. The current population is unknown, however, following El Nino the population is known to have decreased to below 65% of its former number (Hays, 1984).

In captivity

The captive population of the Humboldt Penguin is decreasing (Blay, 1995) and therefore many zoos are carrying out research to find out why this is and what, if anything, can be done about it. In most zoos they are fed frozen fish, and due to the limitations of this diet, considerable attention has been given to their feeding as a possible variable/experimental factor (Wallace et al. 1992). In the wild their diet consists mostly of anchovies and anchoveta (Blay, 1998) which together with the availability of other fish may mean that vitamin levels are higher in wild birds. This coupled with the fact that vitamins A and E have important roles in reproduction were among the major factors when deciding on this study.

At BirdWorld

BirdWorld has kept Humboldt Penguins since 1983. During this time, data have been recorded on breeding patterns, matings and the number of

fertile eggs and chicks produced. It has a very successful history of breeding this species and has produced well over 300 birds. The average production rate has varied each year, and any decrease in numbers may be due to many reasons including ageing birds and changing weather patterns. Nonetheless, it was decided that a research project was in order to determine whether changing their food could increase the production of penguin chicks.

Methods

Study site

The study was carried out at BirdWorld, Holt Pound, Farnham, Surrey GU10 4LD, UK. The captive colony is housed in an open display enclosure, with a freshwater pool, rocky area and off-show nest-boxes. It comprises 14 adult Humboldt Penguins in seven pairs and various offspring bred there last year and all hand-reared at BirdWorld. The adult birds' ages range from 13 to 20 years old (the exact hatching dates are to be found in Appendix 1). Humboldt Penguins are thought to reach sexual maturity at two years of age but their optimal breeding age is unknown. Because of the small size of the population, it was decided to use all birds in the experiment rather than have a control group.

Diet

The birds are fed on a diet of frozen Sprats *Sprattus sprattus* kept at an average temperature of -20°C (-4°F), then defrosted in cold water overnight and/or running water. The Sprats were analysed for vitamin A and E content, during the course of this experiment. Vita-Zu tablets are added to replenish any vitamins lost through the freezing process. Many zoos keep fish frozen for periods of over six months, and prolonged storage can cause depletion in vitamin E (Gailey-Phillips et al. 1982). Salt tablets are also added to their diet, to compensate for the salt they would normally acquire from the seawater. The tablets are fed in about 30 fish (one Vita-Zu and one Salt tablet per Sprat) every two days. The number of these fish that each individual penguin receives is random and would vary each time. It is difficult to be any more precise without causing undue stress to each bird. Vita-Zu tablets contain 1650 IU vitamin A and 25 IU vitamin E per tablet.

Sprat analysis

Frank Greenslades supplies the sprats; deliveries are normally annual in October/November. Once the fish are caught they are put on ice and frozen within 12 hours and upon delivery, BirdWorld store the fish in a freezer and defrosts the appropriate quantity overnight for the next day's consumption. They were tested by dry weight analysis for vitamins A and E by Medlab (MacDonald Exotic & Domestic Laboratories).

Blood samples

Initial tests

On January 10th 2001 during routine veterinary health checks all the adult penguins had 2ml of blood taken from the carotid artery and some of this was used to analyse for the levels of vitamin A and vitamin E. As much as possible was done to minimise the stress to the penguins during this procedure. The penguins were sectioned off from the pool at 8.00am, when most of them are in their nest-boxes anyway. They had not eaten since 3.30pm the day before.

Re-testing blood

As blood sampling is a stressful procedure, it was decided not to repeat the analysis after supplementation of vitamins A and E. Instead a comparison of reproductive performance with previous years was used to assess the benefit of additional supplementation.

Supplementation

This consisted of injecting 1000 IU (0.02ml) liquid vitamin A (Vitamin A Palmitate Ampoules - Cambridge Selfcare Diagnostics Limited) into a Sprat, then adding 25 IU ($\frac{1}{4}$ tablet) vitamin E (Tocovite 100 tablets - Arnolds Veterinary Products Ltd.) in tablet form. Each bird was hand fed one fish each per day for a period of five days. If any bird did not voluntarily eat the fish, they were not force fed, as it was felt this would be detrimental to the project and increase stress levels in the birds. The penguins' supplementation was given regularly through the breeding season daily for five days then discontinued for nine days. The usual dietary supplementation was continued as usual.

Results

Behaviour affecting dosage time

During the early hours of the day (8.00am - 9.30am) the penguins are all in their nest-boxes and not interested in food. At 11.30am, the penguins receive their first feed of the day, and there is usually minimal interest, likewise after 4.00pm when the birds are winding down. However the 3.30pm penguin feed finds most or all the birds in the water and very hungry. Therefore after some basic experimentation it was found that the best time of day to feed the supplemented fish was around 2.30pm - 3.00pm so as to ensure the penguins were hungry enough to eat their tablets/fish. It is worth noting however that this is not always the case at other times of year, for example, during moulting most adults have little appetite at all (Williams et al. 1989).

Sprat testing

The vitamin content of the Sprats compared to other fish (dry matter comparisons) commonly used to feed captive penguins (Crissey et al. 1998) is detailed below. The Columbia River Smelt contains significantly higher levels of both vitamins with Trout also high, whereas all other fish appear to be on a par with each other.

Figure 1. Comparison of various fish and their vitamin contents. Sprat analysis obtained from BirdWorld sprats and the data of Capelin, Herring, Trout and CR Smelt having been taken from Crissey et al. 1998.

Fish	Vitamin A (IU g ⁻¹)	Vitamin E (IU kg ⁻¹)
Capelin	18.2	18
Herring	6.2	5.8
Trout	10.9	70.2
CR Smelt	232	142
Sprat	12.3	2.7

Figure 2. This year (2001) has had a marginal improvement on last year but still does not compare favourably with previous years.

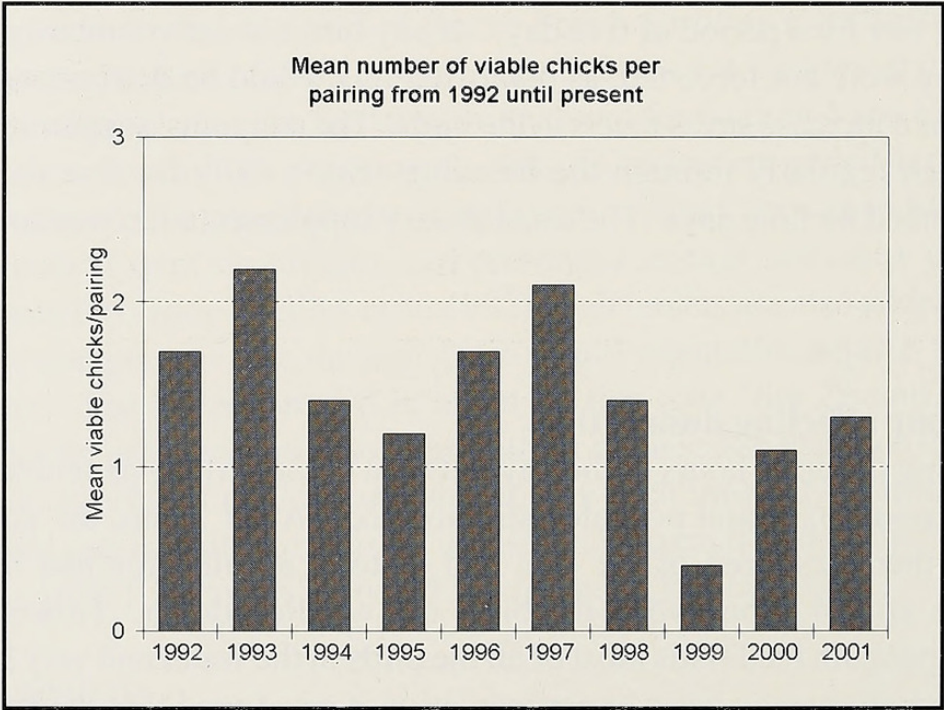
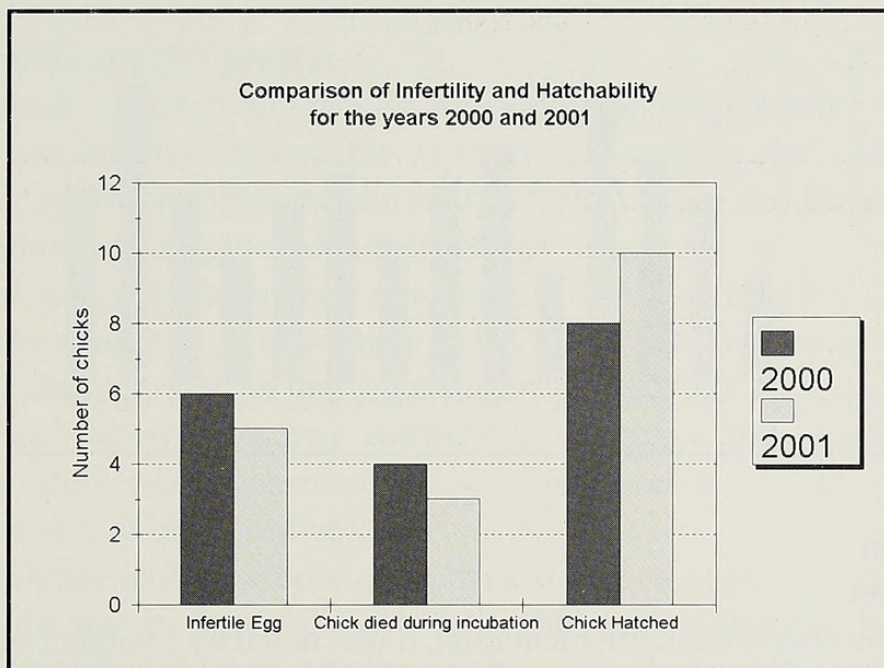


Figure 2 shows the mean number of viable chicks produced per pairing from 1992 to present (2001). In general, the number produced in 1999 reached a low and since then has improved again. This year there were two clutches, in the first 11 eggs were laid but three were infertile. Two of those three came from one pair in which the male, 566, is thought to be infertile as he has only successfully sired offspring once, in 1992. Unfortunately his

current partner, female 718, was a successful breeder with another male up until 1998 when he died. Due to the lack of 'spare' males she paired with the infertile male and has not had any offspring since and this may have adversely affected the mean viable chicks per pairing.

Figure 3. A comparison of mortality of eggs and chicks compared to last year shows visible improvement.



In the second clutch, seven eggs were laid, two were dead in the egg and two were infertile. Of the three penguins which hatched out of the second clutch, one died due to an incubator failing.

Figure 4. Vitamin A levels found in each penguin prior to each supplementation.

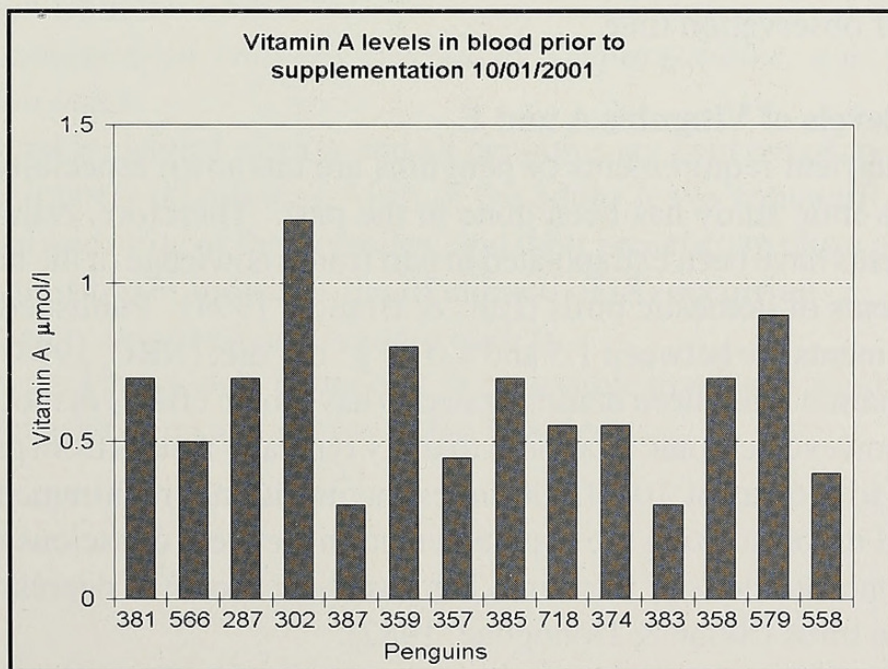
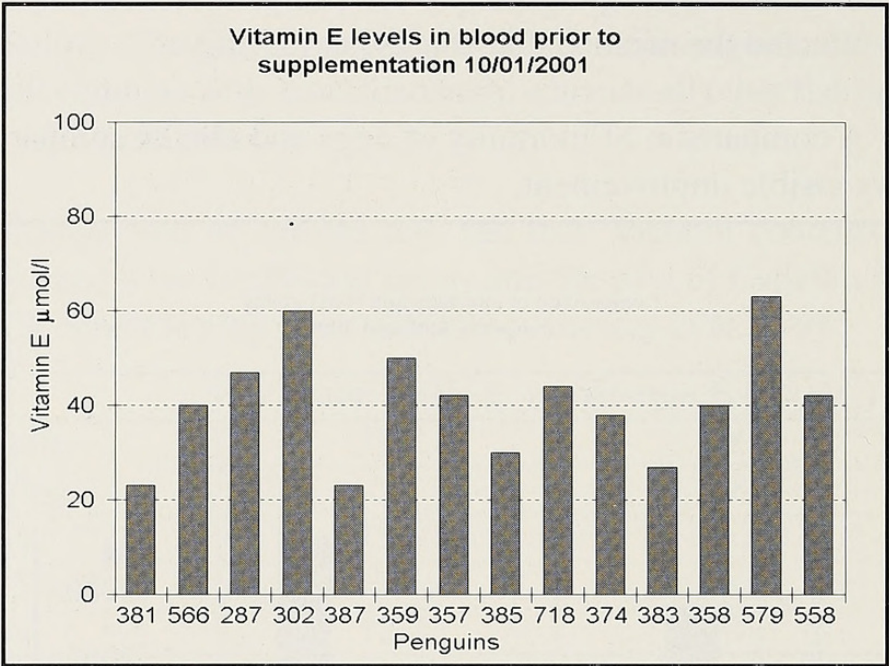


Figure 5. Vitamin E levels found in each penguin prior to supplementation.



Discussion
Copulation

Over the course of supplementation, it was noted by a number of keepers that the penguins were observed to be copulating more than previous years. We believe that, visually speaking, the change in diet increased copulation (Jenkins & Banks, 2001), therefore improving the chances of reproductive success.

Observations were made during general keeping duties. These duties include feeding twice a day, cleaning the pond and checking nest-boxes. Such duties are performed on a regular basis each year and offer a consistent amount of observation time.

Normal levels of Vitamins A and E

The nutrient requirements of penguins are unknown especially for this species as little study has been done in the past. Therefore, estimation of requirements have been extrapolated in part from knowledge of the nutritional requirements of domestic birds (Ellis & Branch, 1994). Published vitamin A requirements are between 1.5 and 4.0 IU g⁻¹ dry diet (NRC, 1994). Excess dietary vitamin A has been demonstrated to have toxic effects in most species studied, however, chronic vitamin A toxicity typically results from prolonged exposure to intakes of 100-1,000 times the nutritional requirement (NRC, 1987) and in formulating the supplementation we were conscious that high dietary concentrations of vitamin A has also been shown to depress vitamin E status in birds (Sklan & Donoghue, 1982).

Another possible problem in apparent fluctuating fertility levels may be that the size of the population can also affect breeding. In captivity it is recommended that Humboldt Penguins be kept in groups of at least six but ideally 15-20 birds (Schmidt, 1978). This is because six birds are the minimum number required for eggs to be laid. At BirdWorld, although the number of adults (14) remained constant throughout the experiment, this year, the number of juveniles fluctuated from eight to two.

Factors affecting the project

1) *Problems administering one vitamin modified fish per bird*

This was appetite dependable as much as anything else. There were some days when some penguins did not eat anything and some when the penguins would fight over a fish and tear it in half.

2) *Inconsistency in the amount of vitamin E due to cutting technique*

A knife was used to score then halve the tablets but invariably some would disintegrate and uneven dosages would affect the experiment.

3) *External factors affecting mating, e.g. weather, fish quality, water temperature, public interaction, keeper interaction*

This is almost unquantifiable.

4) *Interference with nest-boxes and birds sitting on eggs*

If a bird was in the nest-box when supplementation was due, the lid would be lifted and several non-evasive attempts would be made to feed the bird the fish. If this failed, the fish was left in the nest-box in the hope that it would be eaten later.

5) *Interference of last years' offspring interacting with adult pairs*

There are ten nest-boxes and seven adult pairs, usually each pair sticks to a particular box, and therefore three are empty. However the juveniles would often walk into occupied nest-boxes resulting in an aggressive reaction from the adults.

6) *Bird behavioural changes caused by keeping duties, e.g. cleaning penguin pond*

The pond is cleaned weekly and all penguins are kept out of the pool for approximately 90 minutes. Most of the adults leave voluntarily but this is not always true of the juveniles, and their presence in close proximity to the nest-boxes increases the likelihood of (5) occurring.

7) *Our own regular salt and vitamin tablets*

As detailed previously under diet, it is possible that these regular tablets could mask the results shown in the blood tests.

Conclusion

One of the main reasons for undertaking penguin research at BirdWorld was to make a positive impact on the birds, but also to offer recommendations for other zoos. With this in mind, we suggest that it is essential for zoos to supplement penguins' fish with vitamin tablets. This supplementation needs to be vigilant so as to get the best results. Another suggestion may be to monitor the use of frozen fish and to develop a system (if not already in place) to limit prolonged frozen storage. Undertaking blood sampling of the penguins is also a major operation worth mentioning. We found that such a procedure should be limited to a minimum and planning and practice is required prior to the commencement of the study.

Future experiments could include re-sampling the blood post supplementation and looking at hormone levels in the blood as a measure of fertility and/or adding zinc as a soluble salt to aid vitamin E uptake. Originally the project was going to be altering photoperiod, but this proved too difficult at BirdWorld. Another project, which was discussed in the early stages, was cloacal sampling of post-copulated females to examine sperm activity. This would have been costly in terms of observation time required and also would have been an evasive procedure, requiring a license from the Home Office. This has been performed previously on wild Adelié Penguins *Pygoscelis adeliae* (Hunter, 1996).

It has been suggested that vitamin A and E deficiencies may result in reduced fertility, reduced egg hatchability, birth defects, high chick mortality and suppressed immune systems (Crissey, McGill and Simeone, 1998). We believe that vitamin A and E supplementation was successful in our case as the penguins were observed to be copulating more, the number of viable chicks produced increased compared to the previous two years and there was a reduction in mortality rate.

Fertility research performed on Humboldt Penguins has a limited history. For this reason, we believe that to obtain more valid results, it is necessary to continue the project over a number of breeding seasons, and encourage other zoos to try similar studies.

Acknowledgements

Above all we would like to thank Jason Waine B.Vet. Med. MRCVS for his continued assistance and time throughout the project. Also Edward Partridge B.Sc for reading related work, original drafts and comments. We would like to thank the BirdWorld education and keeping staff for assistance, ideas and encouragement and Dr Peter Hopkins for original ideas and guidance. Gratitude also goes to Kerry Banks, BirdWorld's Head Keeper, for her exceptionally well kept penguin history files! Last, but not least, the generous public, members, family and friends who donated money for the costs of this project and without whom it would not have been possible.

References

- Crissey, S. et al. 1998. Influence of dietary vitamins A and E on serum α - and γ -tocopherols, retinol, retinyl palmitate and carotenoid concentrations in Humboldt penguins. *Com. Bio Phy. Part A* 121:333-339.
- del Hoyo, J., Elliot, A. and Sargatal, J. (eds.). 1993. *Handbook of the Birds of the World*. Vol 1. Lynx Edicions. Barcelona.
- Ellis, S., Branch, S. (eds.). 1994. *Penguin Husbandry Manual*. American Zoo and Aquarium Association, Bethesda, MD.
- Gailey-Phillips, J. and Sladden, W. 1982. Survey on Nutrition of Penguins. *J Am Vet Med Assoc.* 181:1305-9.
- Hunter, F.M., Davis, L.S. and Miller, G.D. 1996. Sperm transfer in the Adelié penguin. *The Condor* 98:410-413.
- Jenkins, R. and Banks, K. 2001. *Personal communication*. BirdWorld.
- National Research Council. 1987. *Vitamin tolerance of animals*. National Academy of Sciences, Washington, DC.
- National Research Council. 1994. *Nutrient Requirements of Poultry*. National Academy of Sciences, Washington, DC.
- Schmidt, C.R. 1978. Humboldt penguins at Zurich Zoo. *Int. Zoo Yb.* 26:47-52.
- Sklan, D. and Donoghue, S. 1982. Vitamin E response to high dietary vitamin A in the chick. *J Nutr* 112:759-765.
- Wallace, R. et al. 1992. The effect of dietary vitamin A (retinol) and vitamin E (alphatocopherol) on serum status of Humboldt penguins. *SPN* 5:1:14-20.
- Williams, G. et al. 1989. Plasma α -tocopherol, total lipids and total cholesterol in wild rockhopper, magellanic and gentoo penguins before and after moulting. *The Veterinary Record*, June 3: 585-586.

Appendix 1

Hatch Dates

Males		Females	
287	13/04/81	358	20/03/83
302	03/12/81	374	30/04/83
357	09/03/83	383	31/05/83
359	22/03/83	385	28/06/83
381	30/05/83	558	15/03/88
387	01/07/83	579	14/04/87
566	07/04/87	718	12/12/88

Appendix 2

Current pairs

Male	381	566	287	302	387	359	357
Female	385	718	374	383	358	579	558

Appendix 3

Pairings and viable offspring 1992 - 2001

1992			1993			1994		
Male	Female	V.O.	Male	Female	V.O.	Male	Female	V.O.
354	U	1	287	374	3	287	374	2
302	358	2	357	U	4	302	358	1
359	351	2	357	351	2	357	719	1
387	383	4	381	385	3	359	579	1
357	U	5	387	383	6	381	385	1
401	579	4	401	579	1	593	718	4
566	558	1	593	718	2	596	610	1
287	374	1	U	718	4	U	719	2
			U	U	1	U	U	2
1995			1996			1997		
287	374	1	302	383	3	287	374	3
302	383	2	357	719	1	302	383	3
357	719	1	259	579	1	359	579	1
359	579	1	381	623	1	357	623	1
381	385	1	387	358	3	381	385	3
387	358	1	593	718	4	387	358	2
593	718	1	U	385	2	593	718	4
596	623	3						
U	U	1						
1998			1999			2001		
287	374	1	302	383	3	302	383	3
302	383	2	2000			357	558	2
357	558	4	287	374	2	381	385	2
359	579	2	302	383	2	359	579	1
381	385	1	357	558	1	287	374	1
387	358	1	381	385	3			

Kelly Rose BSc is now doing a PGCE course at Southampton University and hopes to become a secondary school teacher. Until June 2002 she can be contacted by e-mail: kjr201@soton.ac.uk

Caitlyn Hopkins B. App. Sci. H.M.S. Ed has returned to Australia.

COUNCIL MEETING

A council meeting was held on Sunday, October 14th at Chestnut Lodge, Cobham, Surrey.

The following members were present: Miss R. Ezra (President), K. Dolton, Prof. J. R. Hodges, C. J. S. Marler, R. C. J. Sawyer (Vice Presidents), M. Curzon, M. Ellis (Hon. Editor), Mrs L. Gardner, R. H. Grantham, N. Hewston, R. E. Oxley, S. Pyper, P. Schofield, J. Trollope, Ms R. Wiseman. L. Gardiner joined the meeting following his election as the new Hon. Secretary/Treasurer. C. J. S. Marler took the chair and was later elected Chairman.

At the start of the meeting a minutes silence was observed in memory of our late Chairman Ken Lawrence. Apologies for absence were received from Mrs D. Holloway and Dr R. Wilkinson, after which the minutes of the previous meeting were approved and were signed by the Chairman.

Miss R. Ezra, Prof. J. R. Hodges, C.J.S. Marler, Dr H. Quinque, R.C.J. Sawyer, M. Ellis, M. Curzon and S. Pyper were each re-elected for a further five-year term. It was agreed to invite J.A.Ellis to join the council, an invitation which we are pleased to say he has accepted.

The Hon. Editor gave a brief and concise report. The valuable assistance from Mrs June Sherborne was noted and the Hon. Editor was thanked for his efforts.

After much discussion, it was decided that the D. H. S. Risdon Award for the best article in the magazine during 2000, should go to Susan Congdon and Bill Zima for their account of the breeding of the African Jaçana *Actophilornis africanus* at Disney's Animal Kingdom (*Avicultural Magazine* Vol. 106, No. 2, pp. 62-73).

In 2000, Ken Ashken generously gave the society a sum of money to create the Dulcie Cooke Award in memory of his late mother. The council decided that this award, an engraved plaque, should be given annually for what in the council's opinion is the best photo submitted to illustrate an article in the magazine. Again there was much discussion, with the majority of members voting in favour of the award for 2000 going to Theo Pagel for his photos showing the nest, egg, nestling and newly fledged Elegant Pitta *Pitta elegans* at Cologne Zoo (*Avicultural Magazine* Vol.106, No. 4, pp.166-167). It noted that the nestling of this species appeared to be undescribed prior to the publication of his photo.

Five potential first breedings in Great Britain or Ireland were considered and all approved. The society's medal was awarded to: I. Hinze for the Mali or Kulikoro Firefinch *Lagonosticta virata*; R. H. Grantham for the Purple-bellied Parrot *Triclaria malachitacea*; R. C. J. Sawyer for the Blue-bellied Roller *Coracias cyanogaster*. The society's Certificate of Merit was awarded

to: Hillside Bird Oasis for the Lesser Flamingo *Phoeniconaias minor*; Blackbrook Zoological Park for the Marabou *Leptoptilos crumeniferus*.

We hope to arrange a visit to the Cotswold Wildlife Park on Saturday, March 23rd 2002, with the President's Garden Party taking place Sunday, July 15th, and have been invited to visit Ken Dolton's collection near Worcester on Saturday, August 31st.

After a splendid lunch provided by our hosts, Miss Ruth Ezra and Raymond Sawyer, the meeting continued into the afternoon. Among the matters discussed were deciding upon a new delegate to attend NCA (National Council for Aviculture) meetings and storing the large number of back issues of the magazine. Lee Gardiner, the newly elected Hon. Secretary/Treasurer, said he would attend the NCA Annual General Meeting and Laura Gardner offered to store some of the back issues at Leeds Castle. We can though no longer store the number we have in the past, and will have to dispose of some of them. So, if there are back issues you want, now is a good time to buy them.

The society remains in a sound financial position, thanks largely to the lower cost of present day printing, generous donations from Vice President Dr H. Quinque and others and the great generosity of our President, Miss Ruth Ezra, who each year donates to the society's funds the money raised by her much looked forward to and greatly enjoyed garden party. Nor should we forget how Geoffrey Greed and Bristol Zoo stepped in and helped save the society and get in onto its present sound financial footing following the death of Harry Horswell. In recognition of this, Geoffrey Greed and Mrs June Sherborne (who is to continue to do secretarial work for the society) have been made Hon. Life Members. Following our departure from Bristol Zoo Gardens, we now have the society's minute books dating back to 1904, and these may provide interesting material for future issues of the magazine.

Improving how the society promotes itself and aviculture, and whether it should have a mission statement were discussed. Also considered was whether or not the society should help fund conservation and research projects, and it was agreed that the Hon. Editor should ask members and groups seeking such funding to submit written proposals for consideration at future meetings.

The Chairman concluded the meeting by thanking Miss Ruth Ezra and Raymond Sawyer for their kind hospitality.

If you have any views about the above and how the society conducts its business, how it might enrol more new members, the content of the magazine or how the website might be improved, we will be pleased to learn your views.



Rose, Kelly and Hopkins, Caitlyn. 2001. "Do Vitamins A And E Have An Impact On The Fertility Of Humboldt Penguins *Spheniscus humboldti* ?" *The Avicultural magazine* 107(4), 167–178.

View This Item Online: <https://www.biodiversitylibrary.org/item/253191>

Permalink: <https://www.biodiversitylibrary.org/partpdf/314896>

Holding Institution

Smithsonian Libraries and Archives

Sponsored by

Biodiversity Heritage Library

Copyright & Reuse

Copyright Status: In Copyright. Digitized with the permission of the rights holder

Rights Holder: Avicultural Society

License: <https://creativecommons.org/licenses/by-nc-sa/4.0/>

Rights: <https://www.biodiversitylibrary.org/permissions/>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.