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Articles submitted for publication should be typed. Authors who work on a Macintosh computer may send articles on disk, since the newsletter is produced on a Mac (using Microsoft Word and PageMaker).

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AAZPA Spheniscus Workshop, 1990

In this issue and the next, we are pleased to be able to reprint papers presented at the March, 1990, Workshop on Spheniscus Penguins. The Workshop was held in Sacramento, California, as part of the Western Regional Conference of the American Association of Zoological Parks and Aquariums.

Workshop organizers Patty McGill (Humboldt SSP Coordinator and Curator of Birds, Brookfield Zoo) and Fred Beall (Curator of Birds, Baltimore Zoo) arranged a full schedule of activities: nine papers, covering a wide range of topics, were presented during the day, followed by a discussion in the evening. These papers will be published in the AAZPA's Regional Conference Proceedings.

The following list shows the titles of all the papers presented at this workshop, and their authors:

- Field studies of the genus Spheniscus. Dr. David Duffy, Institute of Ecology, University of Georgia, Athens, Georgia.
- Molt patterns in Black-footed penguins (Spheniscus demersus) at Baltimore Zoo. Kathy Bennet, San Francisco Zoo, San Francisco, California.
- Patterns of incubation behavior in captive-housed Adelie penguins: implications for long-term penguin breeding programs. Dr. Sue Ellis-Joseph, Minnesota Zoo, Apple Valley, Minnesota.
- Effects of diets on growth rates of Magellanic penguins (Spheniscus magellanicus) at San Francisco Zoo. Nancy Schofield, San Francisco Zoo, San Francisco, California.
- Supplements available and nutrient content of fish fed to Humboldt penguins. Dr. Susan Crissey, Chicago Zoological Society, Brookfield, Illinois.
- Aspergillosis biologic treatment in fungus diseases. Patricia Stoddard, Willamette Laboratories, Portland, Oregon.
- Avian malaria in Black-footed penguins (Spheniscus demersus). Michael Cranfield, DVM, Baltimore Zoo, Baltimore, Maryland.
- Spheniscus penguins from Toronto to Abu Dhabi; an overview of the captive population. Cynthia Cheney, Washington Park Zoo, Portland, Oregon.

Our thanks to the authors and to the AAZPA for permission to reprint these papers. The Workshop papers are also available from the AAZPA, as part of the AAZPA Regional Conference Proceedings, 1990. This volume, containing the dozens of papers from all the Regional Conferences, may be ordered from: AAZPA, Executive Office, Oglebay Park, Wheeling, West Virginia 26003 USA. The cost is $35 to members, $60 to non-members, plus $5 for overseas postage.

Money Matters and Other Newsletter Business

Some readers have inquired about making contributions toward the costs of publishing this newsletter. Arrangements have been made to have such contributions handled by the Treasurer of the Portland Chapter of the American Association of Zoo Keepers, which--along with the Washington Park Zoo--currently finances the printing and postage expenses.

If you or your institution wish to contribute, please send check or international money order, payable to "Portland Chapter, AAZK," to the Editor. Suggested amount is $10. All moneys received will be used solely for costs of producing and mailing this newsletter.

While contributions are very welcome, SPN remains a free publication, thanks to the generous support of AAZK and WPZ.

This issue is the only one for 1990; next spring should see us back to our intended publication schedule of two issues per year.

The newsletter's title has undergone a slight change, with "Spheniscid" being changed to "Spheniscus," since it was pointed out that the former term more properly refers to all penguins (Spheniscidae), not just members of the genus Spheniscus.

Penguin Research: Work in Progress

A new feature, listing current research studies, begins in this issue (see page 21). Let us know what projects are under way at your institution, for inclusion in future issues. A reply form is included in this issue; just fill it out, fold and mail.
Following the presentation of papers at the Spheniscus Workshop in Sacramento, a panel discussion was held, summarizing the material presented, and discussing its implications for captive management, future research programs, etc. This report on the panel discussion was prepared by moderator Patty McGill and is reprinted from the AAZPA Regional Proceedings, 1990.

Members of the panel were: Frederick Beall, Baltimore Zoo; Michael Cranfield, D.V.M., Baltimore Zoo; Susan Crissey, Chicago Zoological Society; David Duffy, Institute of Ecology, University of Georgia; Patricia Stoddard, Willamette Laboratories, Portland, Oregon; and moderator Patricia McGill, Chicago Zoological Society.

Population status

The papers presented during this workshop provided an overview of the status and habits of penguins of the genus *Spheniscus* both in the wild and in captivity. Although none of the four species is listed as endangered, all species deserve to be carefully monitored. The Galapagos penguin (*Spheniscus mendiculus*) population fluctuates naturally but seems stable. Numbers of Humboldt penguins (*S. humboldti*) have declined seriously, especially in Peru. Likewise Magellanic penguins (*S. magellanicus*) have declined in the Pacific colonies, but not in the Atlantic colonies. Overall, Black-footed or African penguins (*S. demersus*) have declined, especially locally. Typically, the species are extremely variable in choosing nest sites as well as food items. In the wild, Humboldts are perhaps somewhat more "nervous" than the other species, and perhaps less variable in their habits.

In captivity, the worldwide populations of both Black-footed and Humboldt penguins are relatively good; there is good founder representation of both species. There is a smaller population of captive Magellanic penguins, but founder representation is still good for the number of colonies. Comparisons of the breeding success of captive Humboldt and Black-footed penguins reveal that overall success of the latter is much greater than for Humboldts. The Black-foot population has laid more eggs per pair, but have a lower hatching rate per egg than Humboldts. However, the juvenile survivorship of Black-foots is higher than Humboldts and thus they maintain a higher fledgling rate. Clear causes for failure of Humboldt chicks have not yet been defined.

Environmental conditions

Based on the patterns of variability in the wild and the breeding rates in captivity, discussion arose regarding the ways in which the captive conditions may be pushing the species beyond the limits of their variability, i.e. are there conditions of captivity that are outside the limits of environmental or other tolerance?

Duffy suggested that in the wild, guano and salt water may act as disinfecting agents; one could test whether the practices of constant cleaning and use of fresh water allows increased growth of pathogens. Alternatively, perhaps a high level of hygiene decreases development of resistance or immunity in the birds. Field workers remarked on the very high levels of guano and "messiness" of wild colonies.

Dee Boersma (University of Washington, Seattle) also noted that levels of relative humidity in captivity may typically be significantly higher than those in wild breeding areas, which are often located in very dry locales. Also, typical wild breeding sites are quite windy compared to most captive colonies. Possibilities of testing ways to dry nest caves or boxes and/or increase air movement in captive colonies should perhaps be explored. Studies could be conducted to compare wild versus captive breeding sites with respect to their microclimates and levels of pathogens, including the fungus *Aspergillus*.

Medical conditions

The three areas of greatest medical concern are aspergillosis, malaria, and medical problems arising after shipment to a new location.

Cranfield reviewed controlling and monitoring malaria in outdoor colonies. Additional discussion concerned the desirability of developing an ELISA test to identify birds that are immune versus at risk. Particularly when birds are transferred from residence in an indoor colony to an outdoor colony, they should be monitored very carefully. Prevention and treatment should be considered for such individuals prior to the shipment. Cranfield and Beall suggested that Baltimore could assist veterinarians...
and technicians in establishing protocols and in learning to examine samples.

The control of aspergillosis may involve reducing moist environments, improving ventilation, reducing stress, possible vaccination, and effective diagnosis and treatment. It seems that post-shipment birds may be especially vulnerable to succumbing to aspergillosis. Studbook data could provide the basis for analyzing post-shipment mortalities for both Blackfooted and Humboldt penguins. Controlled studies should be conducted to examine the efficacy of an aspergillosis vaccine (see Stoddard) versus prophylactic treatment. Baltimore and San Francisco have used the vaccine in their penguins and could potentially check for a change in titer.

Because post-shipment birds may be vulnerable not only to malaria and aspergillosis, but also to other medical problems, every effort should be made to reduce stress. Particular attention should be paid to lighting regimes, temperatures, diet and nutritional supplements, social setting, and availability of "burrows." Because these are colonial birds, strong consideration should be given to shipping birds together to a new destination, or providing companionship in quarantine. Attention must be paid not only to the conditions of the new colony but also the quarantine setting regarding all the above parameters. Where differences exist between old and new institutions, consideration should be given to changing the conditions gradually.

Diet and nutrition

Field biologists suggest that "high fat" fish or high caloric intake may be important for wild birds, particularly during the breeding season. (However, there are not complete data on the fat or energy content of wild diets.) Such a diet may be critical not only as food for the young, but also in allowing the adults to maintain condition while they are intensively foraging to provision their young. Boersma suggested that total calories or fat may be more limiting than protein; in years when squid formed a major part of wild diets, there was lower fledgling success than in years when the diet was based on anchovies and other fish. Duffy cited evidence from African colonies in which changes in the diet to leaner fish were associated over time with declines in those local populations.

Based on topics discussed and questions asked, Crissey provided additional information.

Fat Content of the Diet

Although the actual levels of fat and energy in the diets of freeranging penguins are unknown, it appears that they consume an array of fish species containing varying levels of nutrients. In particular however, it was observed that large quantities of anchovy were consumed by freeranging Humboldt penguins. It should be noted that there are some data available on the nutrient content of whole anchovy (Sidwell, V.D., NOAA Tech. Memor. Nat. Mar. Fish. Serv. F/sec-11, 1981). These data are presented as percent nutrient on a dry weight basis:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Whole raw Pacific anchovy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>29.7</td>
</tr>
<tr>
<td>Energy</td>
<td>?</td>
</tr>
<tr>
<td>Protein</td>
<td>55.9</td>
</tr>
<tr>
<td>Fat</td>
<td>16.16</td>
</tr>
<tr>
<td>Calcium</td>
<td>?</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>?</td>
</tr>
</tbody>
</table>

A comparison of the fat content of the fish that were discussed is thus:

- capelin: 14.83%
- anchovy: 16.16%
- herring: 34.00%
- mackerel: 39.46%
- Columbia River smelt: 42.88%

A comparison of fish caloric and nutrient contents coupled with the scant information about the complete diets of these penguins in the wild suggests that it may be not only the nutrient content of the fish fed, but also (and perhaps more importantly) the quantity of fish fed and caloric value of the diet that leads to successful breeding and rearing of penguins. Until more is known, it appears prudent to feed a variety of whole fish to penguins in quantities adequate to supply energy and protein needs. If problems arise, particularly with chick survival, the method of feeding and supplementing each animal should be reviewed. It does not appear necessary to supply additional fat in the diet. Finally, it must be noted that the addition of fat or oil to the diet, will dilute other nutrients.

Vitamin Toxicity

Although supplementing some nutrients in an all-fish diet may be recommended (see Crissey), it is possible to induce toxicities from over-supplementation. The symptoms associated with chronic vitamin A toxicity include alopecia, anorexia and weight loss, general weakness and fatigue, bone changes, hepatocellular damage, excess mucus formation, inhibition of normal keratinization, thickened skin, and dermatitis.

please turn to page 11
Supplements Available and Nutrient

THE PURPOSE OF THIS PAPER IS TO REVIEW FIVE ASPECTS OF PENGUIN NUTRITION:
1) selection of foods offered, 2) nutrient content of the diet, 3) probable nutrient requirements, 4) possible vitamin toxicities, and 5) nutrient supplementation. The information presented can be applied to penguins other than Humboldt Penguins (Spheniscus humboldtii) since our knowledge is limited as to the actual nutrient requirements of any of the penguin species.

Selection of foods offered

Most captive penguins are fed frozen/thawed fish. Because daily food availability is crucial to any captive program, most food purchases are made in bulk. This necessitates freezing and storing the food until use. Selection of foods offered, and nutrient content of the diet become critical in the successful management of captive Humboldt penguins.

To avoid ultimate dependence on one particular food item, it is prudent to offer a variety of items to the animal. If the animal becomes fixed on a specific food item and if that supply for some reason becomes unobtainable, it may be very difficult to coax the animal to change. In addition, offering a variety of food items will help assure a complimentary nutrient profile in the diet.

To offer a variety of fish at any one time, it is often difficult to avoid storing food items for an extended period, due to the seasonality of fresh catches of some species. There are two approaches to offering food throughout the year. One approach is to offer items on a seasonal basis, so that the items are stored for less time. The advantage is that relatively fresh fish will be fed. The disadvantage is that possibly only one type of fish will be offered during any one period and, if it is a less preferred fish, or the catch is bad, there may be no backup supply on hand. The alternate approach is to seasonally obtain the catch but store the items and spread their use evenly throughout the year. The advantage is that there will always be fish available and several types of items can be fed simultaneously. The disadvantage is that frozen fish may lose nutrients over time. It has been suggested that maximum storage time for fish be 6-8 months (Geraci, 1986).

Types of fish selected can be chosen for quality, specific nutrient content, availability and price, and for animal preference. It is wise to consider quality a major factor. Human quality items should be insisted upon and the holding conditions must be monitored. Any item which, upon receipt, appears to have undergone degradation or shows evidence of thawing should not be accepted. Consult the Draft Code of Practice for Frozen Fish (Organization for Economic Cooperation and Development and the International Institute of Refrigeration, 1969) for proper storage procedures.

Nutrient content of the diet offered

Most of the nutrient data available for fish refers to that consumed by humans which has been deboned and cleaned free of scales and GI tract. Limited information is available on the nutrient content of whole fish fed to penguins. It must be noted when examining the nutrient data for these items, nutrient content can vary radically among species, among individual lots within a species, among individual fish within a lot, as well as during storage. Thus, published values may or may not reflect the nutrients fed to the penguins at any one specific time. Table 1 shows a compilation of some of the most recent data available for a number of food species commonly offered to captive marine animals.

Nutrient requirements

Because there are no studies that determined the actual nutrient requirement of penguins, the best possible estimation of requirements is derived from domestic species.

In general, a variety of good quality whole fish should provide adequate levels of nutrients for penguins, however considering possible storage losses and potential supplementation problems, several nutrients are highlighted in Table 2a.

Vitamin toxicities

Fat soluble vitamins (A,D,E,& K) are stored in the body and thus it is theoretically possible to feed these vitamins to toxic levels. It is felt that vitamin E is not extremely toxic although recent reports have shown that there may be problems with oversupplementation of vitamin E at 550 to 10,560 mg/kg of dry diet (Nichols et al., 1989). Vitamin K also has been shown to be non-toxic in its natural form (phylloquinone) and the toxic level of an alternate form (menadione) is at least 1,000 times the dietary requirement. (Machlin, 1984.)
Content of Fish Fed to Humboldt Penguins

SUSAN D. CRISSEY

Vitamins A and D may have toxic effects when fed in excess, however. The form of vitamin D utilized best by birds is D3 (cholecalciferol). Some National Research Council (NRC) (National Research Council, 1987) published chronic toxicity levels for vitamin A and D3 are shown in Table 2b. There have been no definitive vitamin A or D toxicity parameters outlined for penguins. Since fish naturally contain considerable levels of vitamin A and possibly D3, animals such as penguins may have a higher tolerance (and possibly even a higher requirement) for these vitamins than do the domestic species upon which these values are based.

Nutrient supplementation

As mentioned above, storage is known to affect the nutrient content of fish. The greatest concern is the loss of thiamin and vitamin E. Some species of fish contain the enzyme, thiaminase, that destroys thiamin during storage. Species thought to have considerable quantities of thiaminase are mackerel, herring, and smelt. Marine products also contain high levels of poly- and mono-unsaturated fatty acids. Because vitamin E is an antioxidant, the breakdown of these fatty acids during storage causes vitamin E destruction.

Considering the value of Humboldt penguins and our mission of captive propagation, most institutions supplement the diets of their penguins with vitamins and minerals. However, if a variety of high quality fish are fed and they are stored and thawed properly, there may be no need for additional supplementation, other than vitamin E and thiamin.

There are many dietary supplements on the commercial market. One product, Sea Tabs, has been marketed specifically for marine animals for years. Recently this supplement has been reformulated. In addition, there is a new product available, Sea World Marine Vitamins, which is being marketed for marine animals also. Other supplements are not marketed specifically for marine animals but are used by some institutions for penguins.

Table 3 is a review of the nutrient content of four supplements; the Sea Tabs (the most recent formulation), Sea World Marine Vitamins, Vionate, and Sundown Multi-vits + vitamin E + thiamin. The doses compared are those suggested by the manufacturer for animals consuming 0.5 kg food daily. This calculation was based on the average daily fish consumption per bird in the Humboldt penguin colony at Brookfield Zoo.

Because each of these supplements is fed in conjunction with the total diet, it is appropriate to compare supplementation regimes as added to the nutrients present in fish. Thus, Table 4 gives the average nutrients in 0.5 kg of fish plus supplement diet. This total diet can be compared with the requirements and toxicities discussed previously. The data are presented on a dry weight basis. "x" means that the nutrient does not exist or is present in only trace amounts in the supplement and data were not available for content in fish. Note that the quantities for many vitamins and minerals may be higher because of their presence in fish but data are not available to support this.

Conclusion

It appears that a good fish diet can supply the probable requirements for most nutrients for penguins based on their diets in the wild. However, considering the potential deficiency problems with vitamin E and thiamin there is a need to supplement with those vitamins. Many institutions supplement penguin diets with additional vitamins and minerals, such as those presented above. However, before supplementing, care must be taken to reduce the risk of possible toxicities.

References

TABLE 1 NUTRIENT CONTENT OF SELECTED WHOLE FISH *

MACRO-NUTRIENT CONTENT (dry matter basis)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>capelin</th>
<th>mackerel</th>
<th>herring</th>
<th>CR-smelt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (%)</td>
<td>18.77</td>
<td>33.59</td>
<td>27.72</td>
<td>22.69</td>
</tr>
<tr>
<td>Energy (kcal/g)</td>
<td>5.55</td>
<td>6.24</td>
<td>6.33</td>
<td>7.01</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>59.77</td>
<td>38.43</td>
<td>45.34</td>
<td>43.92</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>14.83</td>
<td>39.46</td>
<td>34.00</td>
<td>42.88</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>1.69</td>
<td>1.37</td>
<td>1.66</td>
<td>1.09</td>
</tr>
<tr>
<td>Phosphorous (%)</td>
<td>0.37</td>
<td>0.34</td>
<td>0.39</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*Fish species were: capelin (Mallatus villosus); mackerel (Scomberomorus sp.); herring (Clupea harengus) and Columbia river smelt (Thaleichthys pacificus) (Bernard and Ullrey, 1989).

VITAMIN CONTENT

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>LAB 1*</th>
<th>LAB 2**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (IU/g)</td>
<td>mean = 31.8</td>
<td>mean = 26.9</td>
</tr>
<tr>
<td>S.D.</td>
<td>15.98</td>
<td>7.6 - 63.3</td>
</tr>
<tr>
<td>range</td>
<td>15.0 - 59.0</td>
<td>26 - 58</td>
</tr>
<tr>
<td>Vitamin E (IU/kg)</td>
<td>mean = 55.4</td>
<td>mean = 40.6</td>
</tr>
<tr>
<td>S.D.</td>
<td>48.0</td>
<td>26 - 58</td>
</tr>
<tr>
<td>range</td>
<td>from not detectable to 160</td>
<td>26 - 58</td>
</tr>
<tr>
<td>Vitamin D3 (IU/g)</td>
<td>mean = 4.1</td>
<td>mean = 16.8</td>
</tr>
<tr>
<td>S.D.</td>
<td>5.65</td>
<td>16.8</td>
</tr>
<tr>
<td>range</td>
<td>from not detectable to 16.8</td>
<td>16.8</td>
</tr>
</tbody>
</table>

*Means, standard deviations and ranges for vitamins: A (retinol), E (a-tocopherol) for all items analyzed and D3 (cholecalciferol). Preliminary data were obtained from Lab 1 (Allen, M. unpublished data) and based on one or two lots of each item which had been stored, frozen, for less than 1 year. The species analyzed were: capelin (Mallatus villosus); mackerel (Scomberomorus japonicus); herring (Clupea harengus); salt water smelt (Osmerus mordax); fresh water smelt (Osmerus sp.); whitebait (Allosmerus elongatus) and krill (Euphausia). **Means and ranges for vitamins A (retinol) and E (a-tocopherol) for all items analyzed. The species analyzed by Lab 2 (Dierenfeld, E. unpublished data) were: capelin (Mallatus villosus); mackerel (Scomberomorus japonicus); herring (Clupea harengus); smelt (Osmerus sp.); and butterfish.
TABLE 2a. PROBABLE REQUIREMENTS/RECOMMENDATIONS OF SELECTED NUTRIENTS.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Range (dry diet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A*</td>
<td>1.5 - 4.0 IU/g</td>
</tr>
<tr>
<td></td>
<td>(cats and primates 10 IU/g)</td>
</tr>
<tr>
<td>Vitamin D₃*</td>
<td>0.2 - 1.2 IU/g</td>
</tr>
<tr>
<td>Vitamin E**</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Thiamin***</td>
<td>100-120 mg/kg</td>
</tr>
</tbody>
</table>

***Geraci, 1986.

Note: Sodium is an essential nutrient for all animals; however, it is thought by some that the requirement for sodium is a special consideration for the development of nasal glands of marine birds held in fresh water conditions. If marine fish are fed to penguins, there may be enough salt in the diet to supply sodium needs for those birds held in fresh water conditions. Marine fish may average 0.5% Na; the requirement for domestic fowl is 0.167%. Approximately 250 mg of NaCl/bird/day may be fed to penguins without harm.

TABLE 2b. CHRONIC VITAMIN A AND D₃ TOXICITY LEVELS.*

<table>
<thead>
<tr>
<th>Species</th>
<th>Vit A IU/g feed (dry matter)</th>
<th>Vit D₃ IU/g feed (dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>75</td>
<td>2.8</td>
</tr>
<tr>
<td>Swine</td>
<td>660</td>
<td>4.7</td>
</tr>
<tr>
<td>Cats</td>
<td>3500</td>
<td>2.2</td>
</tr>
<tr>
<td>Goats</td>
<td>186</td>
<td>2.2</td>
</tr>
<tr>
<td>Chickens, growing</td>
<td>15</td>
<td>2.2</td>
</tr>
<tr>
<td>Chickens, laying</td>
<td>40</td>
<td>2.2</td>
</tr>
<tr>
<td>Duck</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Geese</td>
<td>15</td>
<td>1000</td>
</tr>
<tr>
<td>Quail</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Turkeys, growing</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Turkeys, breeding</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>


Please turn to page 8.
Supplements Available and Nutrient Content of Fish...

cont'd from page 7

TABLE 3. NUTRIENT CONTENT OF SELECTED SUPPLEMENTS

<table>
<thead>
<tr>
<th>NUTRIENT</th>
<th>SEATABS*</th>
<th>MARINE VITS**</th>
<th>VIONATE***</th>
<th>SUNDOWN+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vit. A (IU)</td>
<td>6250</td>
<td>4000</td>
<td>330</td>
<td>2500</td>
</tr>
<tr>
<td>Vit D3 (IU)</td>
<td>200</td>
<td>0</td>
<td>33</td>
<td>200</td>
</tr>
<tr>
<td>Vit. E (IU)</td>
<td>25</td>
<td>50</td>
<td>0.18</td>
<td>57.5</td>
</tr>
<tr>
<td>Vit C (mg)</td>
<td>75</td>
<td>50</td>
<td>3.75</td>
<td>30</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>125</td>
<td>40</td>
<td>0.06</td>
<td>25.8</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>2.5</td>
<td>3</td>
<td>0.12</td>
<td>0.85</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>5</td>
<td>0</td>
<td>0.41</td>
<td>10</td>
</tr>
<tr>
<td>Pantothenic acid (mg)</td>
<td>2.5</td>
<td>3</td>
<td>0.17</td>
<td>5</td>
</tr>
<tr>
<td>B6 (mg)</td>
<td>1.5</td>
<td>3</td>
<td>0.02</td>
<td>1</td>
</tr>
<tr>
<td>Fe (mg)</td>
<td>12.5</td>
<td>7++</td>
<td>0.83</td>
<td>9</td>
</tr>
<tr>
<td>Choline (mg)</td>
<td>trace</td>
<td>0</td>
<td>8.6</td>
<td>0</td>
</tr>
<tr>
<td>Folic acid (mg)</td>
<td>trace</td>
<td>0.03</td>
<td>.003</td>
<td>0.2</td>
</tr>
<tr>
<td>Cu (mg)</td>
<td>0</td>
<td>0.75++</td>
<td>0.08</td>
<td>1</td>
</tr>
<tr>
<td>Mn (mg)</td>
<td>0</td>
<td>0.5++</td>
<td>0.11</td>
<td>1.25</td>
</tr>
<tr>
<td>B12 (ug)</td>
<td>7.5</td>
<td>0</td>
<td>0.23</td>
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<td>0.013</td>
<td>0</td>
<td>.005</td>
</tr>
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<td>Ca (mg)</td>
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<td>0</td>
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<tr>
<td>P (mg)</td>
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<td>0</td>
<td>71.8</td>
<td>50</td>
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<td>Co (mg)</td>
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<td>I (mg)</td>
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<td>NaCl (mg)</td>
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<td>15</td>
<td>250</td>
</tr>
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<td>Mg (mg)</td>
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<td>0</td>
<td>0.11</td>
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<td>Zn (mg)</td>
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<td>7.5</td>
</tr>
<tr>
<td>K (mg)</td>
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<td>.005</td>
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<tr>
<td>Se (mg)</td>
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<td>0</td>
<td>0</td>
<td>.005</td>
</tr>
<tr>
<td>Mo (mg)</td>
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<td>0</td>
<td>0</td>
<td>.005</td>
</tr>
<tr>
<td>Vitamin K (mg)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.003</td>
</tr>
</tbody>
</table>

See product information section for manufacturer's information.

* This is the quantity in 1/2 of a new Seatab (Manufacturer's recommended dose is 1/2 to 1 tab every other day or daily.)

** This is the quantity in 1/2 #DV-2.0 vitamin developed to be fed: one tablet for every two lbs of fish fed.

*** This is the quantity in 1.5 g of Vionate.

+This is a supplementation schedule consisting of 1/2 tablet of Sundown Multi vit/min, 50 mg vit E, and 25 mg thiamin and 250 mg salt. Sundown Multi is similar in composition to One-A-Day Vitamins Plus Minerals.

++These are chelated minerals. There are pros and cons of chelated minerals. Many times, because they can be more biologically available than non-chelated sources, problems arise with excesses, or competition with other minerals which may cause deficiencies.
## TABLE 4. NUTRIENT CONTENT OF FISH WITH SUPPLEMENTS (on a dry matter basis)

<table>
<thead>
<tr>
<th>NUTRIENT</th>
<th>SEA TABS*</th>
<th>MARINE VITS**</th>
<th>VIONATE**</th>
<th>SUNDOWN+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vit. A (IU/g)</td>
<td>80.5</td>
<td>62.8</td>
<td>33.8</td>
<td>51.2</td>
</tr>
<tr>
<td>Vit D3 (IU/g)</td>
<td>5.6</td>
<td>4.04</td>
<td>4.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Vit. E (mg/kg)</td>
<td>251.2</td>
<td>448.0</td>
<td>55.5</td>
<td>509.0</td>
</tr>
<tr>
<td>Vit C (mg/kg)</td>
<td>590.6</td>
<td>393.7</td>
<td>29.4</td>
<td>237.2</td>
</tr>
<tr>
<td>Thiamin (mg/kg)</td>
<td>985.5</td>
<td>315.7</td>
<td>1.26</td>
<td>204.0</td>
</tr>
<tr>
<td>Riboflavin (mg/kg)</td>
<td>19.69</td>
<td>23.6</td>
<td>0.94</td>
<td>6.7</td>
</tr>
<tr>
<td>Niacin (mg/kg)</td>
<td>39.37</td>
<td>-</td>
<td>3.22</td>
<td>79.1</td>
</tr>
<tr>
<td>Pantothenic acid (mg/kg)</td>
<td>19.69</td>
<td>23.6</td>
<td>1.33</td>
<td>39.5</td>
</tr>
<tr>
<td>B6 (mg/kg)</td>
<td>11.81</td>
<td>23.6</td>
<td>.16</td>
<td>2.9</td>
</tr>
<tr>
<td>Fe (mg/kg)</td>
<td>98.43</td>
<td>55.12</td>
<td>6.5</td>
<td>71.2</td>
</tr>
<tr>
<td>Choline (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>67.4</td>
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</tr>
<tr>
<td>Folic acid (mg/kg)</td>
<td>-</td>
<td>0.2</td>
<td>0.02</td>
<td>0.002</td>
</tr>
<tr>
<td>Cu (mg/kg)</td>
<td>-</td>
<td>5.9</td>
<td>0.6</td>
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<tr>
<td>Mn (mg/kg)</td>
<td>-</td>
<td>3.9</td>
<td>0.9</td>
<td>9.9</td>
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<tr>
<td>B12 (ug/kg)</td>
<td>59</td>
<td>-</td>
<td>2.0</td>
<td>24</td>
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<tr>
<td>Biotin (mg/kg)</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td>39</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
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<tr>
<td>P (%)</td>
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<td>0.4</td>
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<td>0.4</td>
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<tr>
<td>Co (mg/kg)</td>
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<td>-</td>
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<tr>
<td>I (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>0.2</td>
<td>0.59</td>
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<tr>
<td>NaCl (%)</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.69</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
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<tr>
<td>Zn (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>39.53</td>
</tr>
<tr>
<td>K (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.015</td>
</tr>
<tr>
<td>Cr (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
</tr>
<tr>
<td>Se (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
</tr>
<tr>
<td>Mo (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
</tr>
<tr>
<td>Vitamin K (mg/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* This is the quantity in 0.5 kg fish plus 1/2 of a new Seatab (Manufacturer's recommended dose is 1/2 to 1 tab every other day or daily.)

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Aspergillosis: Biologic Treatment in

THE TREATMENT OF DISEASE CAN BE ACCOMPLISHED THROUGH CHEMOTHERAPY, whether it is antibiotics, aspirin, or a number of chemical preparations, or it can be treated through the stimulation of the immunologic system.

Stimulating the immunologic response gives the animal a chance to build up temporary or permanent immunity to specific diseases.

Because of the ability of the body to generate antibodies against antigens (such as bacteria, viruses, or fungi), formulating biologics for specific isolates offers the veterinarian another tool in controlling these problems. Once the disease is controlled, it may be possible to continue using the biologic as a prophylactic, given periodically.

Although the use of bacterins as a method of therapy has not been well known in past years, there is a developing interest in the animal health community.

Preparation of biologics requires you to have pure isolates. They are grown under monitored conditions until they reach a specific concentration. The product is harvested, diluted, inactivated for safety, sterility, and potency.

There are two types of biologics, autogenous and commercial. An autogenous product is very selective. The specific isolate is taken from the infected source and made up into a solution that is injected back into that same animal.

Commercial products have isolates that may come from any area in the country. The isolate has been cultured for its specificity, so it doesn’t necessarily come from the species that will be the end user. The exceptions are some organisms that are species-specific.

Aspergillus fumigatus and Aspergillus flavus are fairly common fungi. Their spores seem to be ubiquitous. Once a spore has landed on a surface that will provide it with nutrients, it will begin to grow and produce filamentary structures, called mycelia. Mycelia appear to be long-thread-like growths that quickly multiply, producing more filaments. It doesn’t take long, measured in hours, before a mass is visible to the naked eye. The color is usually a bluish green or white.

These filaments entwine into tissue and soon begin using up all the nutrients from the host, replacing its tissue with life-threatening fungal material.

The first encounter that Willamette Labs had with Aspergillus fumigatus was in a black labrador dog (Foster, 1976). The nasal passages and sinuses were completely infiltrated. We made up an autogenous biologic from the fungus culture. Injections were given once a week for five weeks. After three injections, there was a dramatic improvement which continued until the dog was completely asymptomatic.

Soon to follow were two studies using A. fumigatus on birds. Penguins were treated at the Washington Park Zoo in Portland, Oregon, by Dr. Mike Schmidt, and Dr. James Foster used the biologic prophylactically on 32 birds of 13 different species (Stoddard, 1979).

Dr. Doug Yearout began a five-year study on eider ducks in Everett, Washington (Yearout, 1988). He presented his findings at the Association of Avian Veterinarians, in Houston, Texas. It is his belief that “vaccination for prevention of aspergillosis is effective in captive aviculture and in wildlife rehabilitation situations for certain sensitive species.”

In Wyoming, 23 raptors were also injected prophylactically (Remple, 1980). These birds were followed by Dr. Remple and observed. After one year, only two birds were lost. He too summarized that the biologic had been very helpful in preventing aspergillosis.

Now, more recently, the treatment of five weekly injections has been administered to between 200 and 270 birds, and four tortoises, in 13 different locations. It is still too early to see how this will be tolerated, but after one year, losses from aspergillosis are much lower than previously.

Tentative studies are being considered for booster shots. The general consensus is best results will come from a treatment which:

1) utilizes a multivalent biologic (since at least two species of fungus—A. fumigatus and A. flavus—are frequently cultured from the same source)

2) includes yearly booster shots.

In the manufacture of a commercial product, several steps are needed that do not apply to autogenous biologics. For instance, it is necessary to develop a way of testing the potency. Since we know by observation that the birds are responding, a test is needed to be able to take serum from injected animals and measure levels of antibody-antigen reaction. Various methods can be employed, with the main objective being reproducibility and comparability.

The slides being shown, although all peripheral skin problems, do demonstrate an immunologic response to
Fungus Diseases

pathogenic fungi from using an injected biologic product.

References


Spheniscus Panel Discussion . . .

cont'd from page 3

The symptoms associated with chronic vitamin D toxicity include abnormal calcification of soft tissues especially kidneys, aorta and lungs.

Other Dietary Concerns

In some captive colonies, there may be a pattern of chick mortality at approximately 7 to 10 days. The possibility was discussed that this may be the age when the last of the yolk has been utilized, and therefore calories and/or nutrients may be limiting. The panel was not aware of any data on yolk utilization or yolk sack absorption in penguins. Whenever possible, notes taken during a postmortem examination of chicks should include observations on the presence, absence, or condition of the yolk sack.

Careful studies of wild diets and the nutrient content of those diets especially during the breeding seasons for these penguin species would be particularly valuable to our understanding of captive management. In addition, monitoring parental feeding frequency of chicks, amount per feeding, and whether regurgitated items are wholly or partially digested may allow us to compare some parameters of successful and unsuccessful colonies.

Management direction

Because the exhibition potential, husbandry, management and facilities requirements for the three Spheniscus species in captivity (Black-footed, Humboldt and Magellanic) are very similar, typically an institution will hold at most one of the species. Therefore, it is critical that all three species are managed in close cooperation. Both an SSP and a studbook for Humboldt penguins and a studbook for Black-footed penguins already exist. In order to have the data necessary to manage Magellanic penguins the establishment of a studbook for this species was strongly urged. San Francisco will review the possibility of undertaking that studbook, and will advise the bird curators by the time of the annual meeting whether they will proceed.

It was not felt that additional SSP programs nor a "master SSP" for the three species are needed at this time. However, an official Spheniscus penguin advisory group is recommended to facilitate the most effective management of this group.
Spheniscus Penguins: an Overview of the

This paper has been revised since it was presented in March, to include additional information from new surveys received. -Author's note

PENGUINS OF THE GENUS SPHENISCUS ARE POPULAR EXHIBIT SUBJECTS IN ZOOLOGICAL institutions around the world. In the wild, these birds nest on the coasts and offshore islands of South America and South Africa. Humboldt penguins (Spheniscus humboldtii) inhabit Peru and Chile, Magellanic penguins (S. magellanicus) are found in Argentina and Chile, Blackfooted or African penguins (S. demersus) nest on the South African coast, and the Galapagos penguin (S. mendiculus) is native to the Galapagos Islands. Three of the four species are listed as Endangered (U.s. Endangered Species Act) or Appendix I (CITES), giving increased urgency to attainment of self-sustaining reproductive levels in zoological institutions. A Species Survival Plan has been established for Humboldt penguins in North America, and studbooks are being developed for Blackfooted penguins in North America and Humboldts in Great Britain. Information about other captive populations has not previously been available. This paper presents data on worldwide captive populations of these species, including measures of their current level of reproductive success.

Data collection began in September, 1988, when detailed surveys were sent out by the author, accompanying the first issue of the Spheniscus Penguin Newsletter, to zoos and aquaria known to have held any of these species in the preceding five years. The list of institutions was compiled from various printed sources such as breeding reports in the International Zoo Yearbook, articles in AAZPA Conference Proceedings, and the North American Humboldt Penguin Studbook. Subsequently, dozens of additional institutions were located by means of notices in zoo publications, word of mouth, and assistance from foreign zoo officials. During this period of rapid growth in the number of institutions being surveyed, detailed analysis of survey results was deferred. By March, 1990, the survey had been distributed to 186 institutions, and 110 completed surveys had been returned, for a response rate of 59%.

The following information was requested from institutions:

- Population size, age, sex, and origin
- Reproduction number of pairs, eggs laid / hatched, chicks fledged
- Diet and Nutrition type of fish, supplementation given, seasonal variations in diet
- Exhibit Design dimensions, air/water filtration, temperature and humidity, substrate
- Nestbox Design numbers available, dimensions, substrate, staff access
- Staff Interaction total staff time spent per day, monitoring of chicks in nest
- Medications
- Morbidity and Mortality

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- Nestbox Design numbers available, dimensions, substrate, staff access
- Staff Interaction total staff time spent per day, monitoring of chicks in nest
- Medications
- Morbidity and Mortality

This paper presents data concerning the first two areas: population and reproduction. Analysis of other data is now underway to detect any correlation between husbandry and captive environment, and measures of reproductive success.

Captive Populations of Spheniscus Penguins

As shown in Table I, the world captive population of Spheniscus penguins totalled 1879 individuals. It was composed of 868 Blackfooted penguins, 870 Humboldt penguins, and 141 Magellanic penguins. No Galapagos penguins have been reported. Only eleven instances of hybridization have been noted. All were crosses of Humboldts with one of the other two species; no Blackfooted X Magellanic individuals were reported.

The captive Magellanic population is very small relative to the other two species held in captivity, and is much more restricted in its distribution. It consists of a total of only 141 birds, located in institutions in three countries. U.s. institutions hold 91% of the total. In the case of the much larger population of Blackfooted penguins, U.S. institutions hold 42%, with substantial parts of the population found in the Netherlands (19%), Great Britain (13%), and Canada (6%) as well. For Humboldts, zoos in Great Britain (where a regional Humboldt Studbook is now being established) hold the greatest portion of the population (27%), with the U.S. (19%), West Germany (18%) and Japan (13%) holding the next largest numbers. While the countries mentioned are home to the largest portions of these species in zoological settings, substantial groups of both Humboldt and Blackfooted penguins are found in other countries.
World Captive Population

CYNTHIA A. CHENEY

Table I. Population parameters for captive Spheniscus penguins.

<table>
<thead>
<tr>
<th>Species</th>
<th>no. of individuals</th>
<th>% in small colonies, ≤ 20</th>
<th>% wild-caught</th>
<th>% captive-bred</th>
<th>% unknown origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackfooted</td>
<td>868</td>
<td>39</td>
<td>6.0</td>
<td>79.8</td>
<td>14.2</td>
</tr>
<tr>
<td>Humboldt</td>
<td>870</td>
<td>58</td>
<td>15.3</td>
<td>57.7</td>
<td>27.0</td>
</tr>
<tr>
<td>Magellanic</td>
<td>141</td>
<td>26</td>
<td>65.9</td>
<td>31.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Galapagos</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

including Abu Dhabi, Belgium, Canada, East Germany, France, Hungary, Israel, Peru, and Spain.

Zoo personnel working with these species have hypothesized that social behaviors associated with reproduction are exhibited less frequently in very small colonies. Table I shows the percentage of each population residing in groups of 1-20 individuals. These smaller colonies are substantially more prevalent for the Humboldts. Interestingly, this species also shows less reproductive success than the other commonly held species (Blackfooted penguins), which is predominantly found in larger colonies (greater than 20 individuals).

The three populations vary greatly in respect to origin. About two-thirds of the Magellanes (66%) are wild-caught. Some were taken as adults, others were hand-reared from eggs collected in the wild. It is interesting to note that this last group will technically be described as wild-caught, although they were hand-raised. In contrast, 80% of the Blackfooted penguins are captive-bred, with known wild-caught birds representing only 6% of the population remaining. This is evidently a population that has been established in zoos for some time and enjoys substantial breeding success.

Finally, the Humboldts show another pattern: 58% captive-bred, 15% known wild-caught birds still alive, and a surprisingly large portion, 27%, of birds reported as "origin unknown."

With regard to the age structure and sex ratio of these populations, differences seen are in part due to how long each species has been in captivity, and its subsequent breeding success.

The Magellanic population (Figure 1) contains an unusually large proportion of young birds, aged four years or less. About half were hatched from eggs taken from wild colonies; the remainder are captive-bred. There are very few individuals in the middle age ranges. This population (mostly young, recently established in captivity, and held by only a few institutions) presents an opportunity for the foundation of forward-looking management plans at an early point.

please turn to page 14
Spheniscus Penguins: an Overview of the World Captive

The Blackfooted penguin population (Figure 2, at right) also shows a large cohort aged 0-4 years, in this case characteristic of a vigorously breeding population. Numbers fall off rather rapidly in the older age ranges. Few birds of unknown age exist, and once the birds reach breeding age the numbers of unknown-sex individuals is comparatively low.

Two points stand out in the data for Humboldts (Figure 3, below): at every age the number of unknown-sex birds is high, and there is also an unusually large group of age-unknown individuals, many of which are of unknown sex as well. The high proportion of unknowns here may indicate areas in which management and record-keeping may be improved. Unpaired birds of breeding age should be sexed to be sure that mates are available for them in their colonies. Individuals listed as "age unknown" are presumably wild-caught, probably during the 1970's, and every effort should be made to afford them the opportunity to breed.

Survey returns indicate that sexing and individual identification are areas of management which would benefit from increased attention. The survey asked institutions about methods used to sex penguins, giving the following choices: laparoscopy, cloacoscopy, behavioral observation, chromosomal analysis, hormonal analysis, morphometrics, other, and none. Unfortunately, the most common method for all three species (reported by almost half of the institutions), was "none." Where sexing was done, the prevalent means was by behavioral observation. What this may often mean in practice is that paired birds are sexed, but unpaired ones remain as "sex unknown."

In some cases, it was reported that penguins were not banded or otherwise identified individually (by photographs of spot patterns, for example), which severely compromises all forms of record-keeping, including records of relatedness needed to avoid inbreeding.
Population . . .
cont'd from page 13

Table II. Reproductive performance of captive *Spheniscus* penguins.

<table>
<thead>
<tr>
<th></th>
<th>Historic Breeding season 1987/88</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Fledging Rate: 1987/88</td>
</tr>
<tr>
<td>Blackfooted</td>
<td>0.826</td>
</tr>
<tr>
<td>Humboldt</td>
<td>0.536</td>
</tr>
<tr>
<td>Magellanic</td>
<td>0.459</td>
</tr>
</tbody>
</table>

*This is the total number of eggs laid, divided by the number of bonded pairs, whether they laid or not in that particular year.

**Although some institutions had bonded pairs which did not lay in this year, this was offset by other institutions which reported more laying pairs than bonded pairs, resulting in the 100% figure for this species.

Reproduction in Captive Populations of *Spheniscus*

Reproductive failure in an avian species can occur at many points: birds can fail to pair, or to breed; no eggs may be laid, or eggs may be infertile; fertile eggs may fail to hatch for a variety of reasons; chicks, once hatched, may fail to survive to fledging (which for the species under consideration is at about three months of age). Data concerning each of these points are summarized in Table II.

Fledging Rate was used as an overall measure of each species's reproductive success in zoological institutions. It was defined as: the number of chicks fledged (whether hand-reared or parent-reared) in a given breeding season, per bonded pair. For example, if, on average, each pair hatched one chick which survived to fledging, the Fledging Rate of that population for that breeding season would be 1.00.

The data for 1987/88 show a marked difference in Fledging Rate {Table II} between Blackfooted and Humboldt penguins in captive settings: 0.826 and 0.536 respectively. Magellanic penguins had an even lower fledging rate for that year, 0.459. While this is based upon only one breeding season, the survey also elicited information concerning the reproductive history of pairs, asking how many pairs had ever raised a chick (parent-reared) to fledging. Results are shown in the second column of Table II, "% of pairs which laid." Again, Blackfooted pairs enjoyed the highest success rate (71%), with Humboldts and Magellanes showing markedly lower rates (38% and 27% respectively).

Where in the reproductive cycle does this difference arise? To investigate in more detail the reproductive differences between these species, both the structures of the populations, and the data reported for breeding season 1987/88, were examined.

The first step in the annual reproductive cycle on which data are generally kept is egg-laying. In 1987/88, the average number of eggs laid per pair was 3.04 per pair for Blackfooted penguins, and only 1.9 for Humboldt pairs and 1.27 for Magellanes. Since the normal clutch size for these species is two eggs, the data indicate a substantial incidence of double-clutching by Blackfooted pairs. The lower number for the other two species may result from abnor-

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Spheniscus Penguins: an Overview of the World Captive

When the chick-fledging success for these species is examined with regard to rearing method, a dramatic difference appears (Figure 4). Most Blackfooted chicks were left with their parents, and most of those (70.7%) survived to fledging; a smaller proportion of Humboldt chicks remained with the parents, and the majority died in the nest, only 40.4% surviving to fledging. The number of Magellanic hatchlings was small (19 chicks); of these, over half were parent-reared, and 81.8% survived to fledging. For hand-reared chicks the fledging rates for Blackfooted and Humboldts were comparable, 79.4% and 74.7% respectively. For hand-reared Magellanic chicks, the fledging rate was again higher than the other two species: 100%.

Thus, while the low number of eggs per pair and poor hatch rate gave the Magellanic the lowest per-pair success rates, chicks which did hatch had an excellent survival rate. The small Magellanic population, which differs so markedly in age structure from the other two, has a preponderance of young, less experienced pairs. Although the influence of age and experience upon parental success has yet to be investigated in these species, some zoological personnel see an association between inexperienced pairs and infertile or poorly incubated eggs. If that is the major factor currently restricting reproductive success in Magellanic penguins, this small population may grow rapidly in the near future, as existing pairs gain experience.

As the other two species of Spheniscus penguins in captivity share a more balanced population structure, this does not seem to be a causative factor for the much lower success rate of Humboldts. To summarize the figures cited earlier, the reported data show the following inter-species differences, between Humboldt and Blackfooted penguins, at successive points in the reproductive process:

In the year under examination,
• Humboldts laid fewer eggs per pair than Blackfooted penguins, and a greater proportion of the pairs failed to lay at all
• The hatching rate is slightly better for Humboldt eggs
• Humboldt pairs had substantially poorer success at parent-rearing chicks, though chicks of both species were successfully hand-reared at about the same rate
• Zoological institutions chose to leave most (82.4%) Blackfooted chicks with their parents. In contrast, slightly more than half (54.6%) of the Humboldt chicks were pulled for hand-rearing.

Given this situation, it would perhaps seem natural to conclude that extensive hand-rearing represents the solution to poor reproductive success in captive Humboldt penguins. Certainly, hand-rearing is an invaluable option under some circumstances:

when a parent dies, a chick becomes distressed, or it is desired to increase, quickly and reliably, a founder bird's contribution to the population. As an across-the-board measure, however, it requires further consideration.

There is a familiar set of pros and cons in regard to handrearing. In its favor, it may be said that once a good protocol has been established, the success rate is very high: 90% success is not an unreasonable expectation. Most American institutions use the protocol developed at Sea World (Sea World, Inc., San Diego, CA), or a slightly modified version of it, and enjoy excellent success. Hand-rearing also provides a very controlled environment, protecting chicks from disease and offering nutrition of a known, high level. It protects chicks from accidents such as getting out of the nest and being pecked, or falling into the pool, or being injured when another bird enters the nest and causes a fight. Also, removing eggs or chicks can cause multiple-clutching and thus increase the reproductive performance of the group.
On the other hand, even for experienced staff, hand-rearing is an extremely labor-intensive process. Excessive multiple-clutching also may adversely affect the birds' vigor and disturb their molt cycles. Effects of hand-rearing on subsequent breeding performance has not, as far as this author can discover, been examined in detail. It is clear that hand-reared Spheniscus penguins are not reproductively disabled to the severe degree reported in hand-reared primates and exotic cats. Many hand-reared Spheniscus penguins do pair, lay and hatch eggs, and raise young. However, it is not known how their success rate at each point compares with that of non-hand-reared birds in their colony, nor is there detailed information comparing, for instance, nest relief and chick feeding patterns, for parents of varying backgrounds.

Furthermore, in addition to potential difficulties with hand-rearing itself, there is what may be called the "masking effect" of hand-rearing. Failure of a species to rear its own young in captivity is presumably caused by some defect in the captive environment, or in the breeding stock. It may be a sign of trouble with the adults, not just with the young. Potential areas of environmental deficiencies to be considered for Spheniscus penguins include light cycle, nutrition (both fish and supplementation), group size, air and water quality, nest box design, and climatic factors.

In this situation, widespread hand-rearing may serve to "mask" the existence of a real problem, creating an apparently successful captive population of Humboldts in which the adults show no acute problems, and the reproductive rate appears good. In reality, reproduction might be dependent upon human intervention, and the population might still be suffering an unknown problem, which could conceivably be intensified in generations to come.

Failures at any stage of the reproductive cycle should be signals and sources of information for us, as we seek to carry out our responsibility to those animals in our care now, and to the future populations which will be based upon our current colonies. As shown by the data presented in this paper, the situation of the world captive population of Humboldt penguins, with its aging group of wild-caught birds and poor reproductive success, would appear to call for intensive efforts to identify and solve its problems.

Analysis of the survey data is now under way, with particular attention to identifying correlates between husbandry practices, or environmental factors, and reproductive success. (Institutions which have not yet contributed to the survey are urged to do so, and every effort will be made to include newly received data in analyses.) Results will be published in the *Spheniscus Penguin Newsletter.*

*Penguin Biology,* edited by Lloyd S. Davis and John T. Darby, was published this summer by Academic Press. It contains 18 of the papers presented at the First International Penguin Conference, held in New Zealand in 1988. Many of these have been revised for publication. Dr. Darby notes that the selection of papers "has largely been based on providing an overview of recent developments as well as new findings, ... [attempting] to cover what has now become a very broad field of sea bird research." Topics covered included breeding, feeding, and foraging; behavior and evolution; energetics and physiology; and new fossil material.


[This is the volume erroneously described in an earlier issue of *SPN* as the forthcoming "Proceedings" of the 1988 New Zealand Conference.]
Gull, Gull, Go Away!

The best management plans can sometimes be hindered by relatively trivial factors that appear "out of the blue." A good example is the appearance of wild scavengers in open-air exhibits, making off with the vitamin-stuffed fish meant for penguins. Here is the tale of one zoo's successful battle with this problem.

The San Francisco Zoo has perhaps the healthiest gull population in the known world, and we accomplished this without even trying.

You see, when you build a zoo right next to the Pacific Ocean—and you have an outdoor Magellanic Penguin exhibit—and you are serving free fresh herring—then you are bound to attract the crafty Western Gull. These winged creatures have got our system figured out. At precisely 9 a.m. and 2:30 p.m., every gull in California descends upon our feeding penguin population. With daring aerial maneuvers these "beasts" can rip the fish right out of the penguins' mouths. Not only is this behavior frowned upon by penguin keepers, it frightens and frustrates the unsuspecting penguins. To make matters worse, the fish being stolen is usually filled with a myriad of quite necessary and expensive vitamins and medications. As our population of beautiful (and legally protected) gulls got bigger and bolder, the keepers and penguins became obsessed with putting a stop to their robbery. Thus began our attempt to find both effective and humane gull abatement methods.

Trust me, we already know that these birds are hip to inflatable owls and rubber snakes. Our ingenuity was to put to the test—and we were determined to succeed where others (i.e. airports, zoos, aquariums, and restaurants) had failed.

First we tried screaming at them; they ignored us. Then we strung dozens of overhead "gull wires"; they simply walked in instead of flying in. Then we arranged to have an Avian Volunteer bring a raptor "on the fist" to the penguin pool for the two daily feedings. This method is quite effective but not perfect. If passive-appearing raptors are used daily, they become less effective. If flighty birds are used every other day, it is more effective. However, when the weather is bad, or if there is a shortage of volunteers or available birds, this method is not always practical or reliable.

Currently we are arranging to use a directional microphone to tape the gulls' distress/alarm call. This can be played back at a later date. This method has been utilized by airports and is said to be somewhat effective if not overused.

But, as we continued our search for the perfect abatement technique, a brilliant idea reappeared. Adjacent to the penguin pool is our river otter exhibit, and occasionally the otters would catch themselves a greedy gull. We noticed that the sight of this lifeless bird sent the other gulls into immediate retreat. With this in mind, we found ourselves a deceased gull from a local wildlife rehabilitation center. Then, we found a remarkable 14-year old taxidermist named Kristi. She, for a mere $60 (or $50 if no eyes are required) preserved forever "Mr. Deadbeat," our beloved stuffed gull, in a very dead-looking posture. Care and feeding of said gull is simple: a closed container and some mothballs. When held aloft in a menacing manner it will scare off all but the stupidest of birds.

The "dead gull" method has proven very effective, if not overused. It is also very important to inform your zoo visitors, through newsletters or on-the-spot explanations, that you did not throttle this poor bird to death, but rather that it died of natural causes and was obtained through proper channels.

In conclusion, I must say that we have succeeded in gull abatement in a most humane way. And, when any or all of these techniques are implemented in some form of rotation, you too can be Gull Free!
Recent Publications


Karen Dale
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Recent Publications


Questions and Answers from Readers

Q. Is brewer's yeast an effective nutritional supplement for spheniscus penguins? What are its advantages and disadvantages?

A. Brewer's yeast is touted as "one of nature's richest foods in B vitamins." This is somewhat of an overstatement. Brewer's yeast is, however, high in B complex vitamins and contains a variety of minerals, protein, fat and energy.

B complex vitamins usually refer to thiamine (B₁), riboflavin (B₂), niacin, pyridoxine (B₆), B₁₂, folic acid, pantothenic acid, biotin, and inositol. Because these vitamins are considered water soluble, they should be present in the diet daily.

Usually, foods of animal origin (example: whole fish) are excellent sources of the B vitamins. Thus, there is probably no need for additional supplementation to a whole fish diet with brewer's yeast.

The only potential problem concerning brewer's yeast is that it may cause intestinal gas and possibly bloat especially if the animals are not used to consuming it.

It must be remembered, however, that if fish is stored for any length of time, thiaminases that may be naturally present will destroy the thiamine in the fish. Thus it is recommended that institutions supplement penguin diets with thiamine at about 50 mg/Kg of fish fed. Due to vitamin E degradation, it is also recommended that it be supplemented at about 100 mg/Kg of fish fed.

answered by:
Susan D. Crissey, Ph.D.
Nutrition Advisor - Humboldt SSP
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Q. Have any readers seen juvenile penguins undergo an early partial moult, getting adult plumage on just the head or head and neck, prior to their first real moult? This has been observed in some wild spheniscus penguins, and it has been theorised that it may allow juveniles to join groups of adults at sea, by "masquerading" as adults.

Q. One of our readers manages a Spheniscus colony which he describes as "free-ranging": the penguins have the freedom of a large planted park, within which they choose nest sites. He asks whether anyone else has a similar situation. Judging from survey returns, this is a very unusual—perhaps a unique—situation; if you've had experience with this sort of captive environment, please share it with other readers.

Research in Progress:
Some Current Studies

The field of spheniscus penguin research is a rapidly expanding one, with many studies being undertaken both in the field and in zoological institutions. Some of the current projects that have come to our attention (mostly through the survey returns) are listed below, with the name of the individual who provided the information.

Photoperiod trial: change from Punta Arenas light cycle to Grand Rapids, Michigan. (S. magellanicus) James R. Klinesteker, John Ball Zoo, Grand Rapids, Michigan, USA.

Nest box design and chick rearing success. (S. humboldti) Steffen Patzwahl, Vogelpark Walsrode, Walsrode, Germany.

Refining accuracy of artificial incubation temperatures. (S. magellanicus) David Oehler, Cincinnati Zoo, Cincinnati, Ohio, USA.

Seasonal variation in swimming time. (S. demersus, S. humboldti) Curator of Birds, Ueno Zoo, Tokyo, Japan.

Analyzing substrates for bacterial growth parameters to shed light on bumblefoot development in rockhoppers, in an exhibit shared with S. demersus. Dan Laughlin, New England Aquarium, Boston, Mass., USA.


Sexing methods for Magellanic penguins and Macaroni penguins. Von Kment, Sea World of Ohio, Aurora, Ohio, USA.

A listing of current research projects will be included in future issues of SPN, as information is received, with the intent of promoting communication between researchers, and encouraging more institutions to devote resources to research on these species.

Please use the separate sheet, enclosed within this issue, to send in details of research projects ongoing at your institution, or inform us by letter.

Articles and summaries of completed research projects, for potential publication in SPN, are welcomed.