Nutrition and Care of the Sporting Dog

IAMS COMPANY

2002 Edition

Preface

This book reflects The Iams Company's interest and commitment to the care and well-being of sporting dogs. It is the intent of the authors that the reader will consult it often, making it a well-worn volume that resides in the kennel office or in the cab of the owner's and trainer's trucks.

This book is designed for all field dog breeds. For simplification, the term "sporting dog" is used in the title, but for the purposes of the authors, terms like "field trial dog", "gun dog", "hunting dog", "upland dog", "waterfowl dog", and "bird dog" are all inclusive. Chapters that use these terms have value for the reader whether they own Beagles, Spaniels, pointing dogs, versatile dogs, or duck dogs.

The authors believe that all these breeds should have the best health, best care, and best nutrition so that dog and owner can enjoy days afield for many years.

Table of Contents

Item #RD0033

Cover photos (from top): ©Bonnie Nance; ©Beth Hanson; ©Kent and Donna Dannen

Guidelines for a Lifetime of Health Care and Nutrition for the Sporting Dog

Today's sporting dogs are truly canine athletes and are products of improved breeding, more sound training methods, and better health care. Just as human Olympic athletes have unique nutritional needs, these performance dogs also require special nutritional management that will provide the best chance for them to exhibit their skills at maximum levels. As breeding and training methods continue to advance, nutrition may prove to be the winning edge.

NEONATAL LIFESTAGE: Birth to Weaning

Health Care and General Management

- Begin internal parasite control as early as 14 days of age; a wide variety of drugs are safe and effective for roundworms and hookworms
- Have kennel veterinarian remove dew claws and/or dock tail per breed standard by age 3 days
- Administer first vaccinations at age 6 weeks, according to the kennel veterinarian's recommendations

Nutrition

- Begin weaning process as early as 21 days of age, depending on breed and puppy condition
  - Eukanuba® Puppy Weaning Diet Formula or Iams® Original Puppy Food are ideal choices

PUPPY LIFESTAGE: Weaning to 24 months

Health Care and General Management

- Maintain vaccination and deworming program per kennel veterinarian's protocol
- Begin and continue heartworm preventive medication as directed by kennel veterinarian
- Permanent identification via tattoo or microchip should be done by age 6 months

Nutrition

- For breeds that will mature to a body weight exceeding 50 pounds, the following diets contain optimal levels of calcium and calories to meet the special nutritional needs of large breed dogs
  - Eukanuba® Puppy Large Breed Formula
  - Iams® Large Breed Puppy Food
- For medium and small breeds
  - Eukanuba® Puppy Small Breed Formula
  - Eukanuba® Puppy Medium Breed Formula
  - Eukanuba® Puppy Lamb and Rice Formula
  - Iams® Original Puppy Food
  - Iams® Lamb Meal and Rice Formula Puppy Food

ADULT LIFESTAGE: 2 to 7 years old

Health Care and General Management

- Maintain appropriate vaccination and deworming schedules as advised by the kennel veterinarian
- Maintain heartworm preventive medication

ADULT LIFESTAGE: continued

- Have the kennel veterinarian design a regular schedule of preventive care for ears, pads, skin, and eyes; ask the veterinarian to design the program so the majority of care can be handled primarily by the trainer or owner with periodic input from the veterinarian
- External parasite control should be maintained per protocol established by veterinarian
- An annual visit by the kennel veterinarian should include a hands-on examination for early injuries or diseases
- Dogs in competition should have an annual blood tests for organ function, blood counts, and other screenings as advised by the kennel veterinarian
- Dogs should be specifically examined for dental problems and the kennel veterinarian should determine the course of action for each dog
- Breeding animals should be tested annually for Canine Brucellosis
- DNA testing should be conducted on animals whose registry requires documentation for breeding

Nutrition

- Dogs in competition
  - Feed Eukanuba® Adult Premium Performance Formula
  - Eukanuba® Large Breed Premium Performance Formula (depending on body size)
    - contains glucosamine and chondroitin sulfate to support joint health
    - contains l-carnitine for fat metabolism
  - Begin feeding 8 weeks before competition or intense training
  - Refer to pages 31–38 "Feeding for Endurance and Performance of Sporting Dogs" and pages 43–48 "Effect of Diet on Hunting Performance"
- Dogs under extreme performance requirements
  - Feed Eukanuba Veterinary Diets® Nutritional Stress/Weight Gain Formula™ Maximum-Calorie™/Canine
  - Helps maintain weight during periods of stress
  - Available only from the kennel veterinarian
- Dogs not in training (feed according to breed size and activity level)
  - Eukanuba® Adult Maintenance Formula (also available in a Small Bite)
  - Eukanuba® Adult Lamb & Rice Formula
  - Eukanuba® Adult Large Breed Formula (depending on body size)
    - contains glucosamine and chondroitin sulfate to support joint health
  - Iams Chunks® or Iams MiniChunks®
  - Iams® Lamb Meal & Rice Formula
  - Iams® Large Breed
    - contains glucosamine to support joint health
- Pregnant bitches
  - Feed Eukanuba® Adult Premium Performance Formula beginning the day of the mating
  - Refer to pages 65–72 "Breeding Management for Success"
- All adult Eukanuba® dog foods contain the Dental Defense System™ to help support good dental health

SENIOR LIFESTAGE: Over 7 years old

Health Care and General Management

- Older sporting dogs should have a thorough annual examination by the kennel veterinarian including a panel of blood tests as recommended
- Be aware if water consumption and urination volumes increase; this could be a sign of kidney disease and the dog should be examined by the kennel veterinarian
  - Refer to pages 39–42 "Dietary Protein and the Kidney in the Field Trial Dog"

Nutrition

- Feed according to activity level, weight, and breed size
  - Eukanuba® Senior Maintenance Formula
  - Eukanuba® Senior Large Breed Formula
  - Iams Active Maturity™

For further details about Eukanuba® and Iams® products

- Call the Iams Consumer Care Team toll-free at 1-800-675-3849
- Or visit these web sites: *www.iams.com* and *www.eukanuba.com*

Management of Health Care in the Large Sporting Dog Kennel

Martin Coffman, DVM

INTRODUCTION

The term "herd health" is commonly used in veterinary medicine, normally in an agricultural setting. The concept refers to viewing health care from the aspect of the entire group of animals as opposed to merely treating individual animals. This model has application in the large sporting dog kennel as well. While individual dogs that are sick or injured must, of course, be treated, the majority of efforts aimed at prevention and treatment of disease should address the entire kennel.

Breeders, trainers, and sporting dog veterinarians are concerned with the following five basic facets of health care for a hunting dog kennel:

1. Overall health care management
2. Nutrition
3. Prevention of viral diseases (vaccinations)
4. Parasite control
5. Treatment of sick or injured animals (while illness and injury are regular occurrences, this topic is outside the purview of this paper and will not be addressed)

OVERALL HEALTH CARE MANAGEMENT

Kennel Types

Hunting dog kennels can be categorized as stable or transient and they can be further described by purpose (breeding, training only, or kennels that primarily travel to events to campaign their dogs).[1] Kennels that reflect long-term breeding programs often have very stable populations of dogs, while training kennels may have complete changeovers in individual animals every few months. Hunting kennels may have a stable core of dogs, but the periodic purchase or sale of animals may effect the population of the facility.

Regardless of the intent of the kennel, all sporting dog kennels share certain characteristics the include 1) some type of animal confinement, 2) close proximity of dogs to each other, 3) a system for sanitation, 4) a nutritional status, and 5) a level of health care.[1]

Despite these common characteristics, kennels do vary depending on location and breed needs. For example, a bird dog kennel in South Georgia has one set of needs, while a retriever kennel in Minnesota has another; each are dependent on environmental conditions. Kennels with on-going breeding programs have an entire set of needs for newborn puppies as opposed to adult dogs in training. In all these kennel settings, without exception, planned prevention of disease is more cost effective and efficient than just treating disease as it occurs.

Spread of Disease

Bacteria and viruses can spread directly from dog to dog or indirectly via food pans, footwear of visitors, or transportation crates. Agents can be airborne or water-borne. These agents vary in their ability to spread and cause disease; some are easily destroyed, while others are very hardy and virulent. Dogs vary, too, in their susceptibility to disease depending on age, inbreeding, and nutritional status. Environmental factors, such as crowding, ventilation, and sanitation also influence the incidence of disease in a sporting dog kennel too. Recognizing the complex interaction of disease agents, close attention to the dogs and overall husbandry are essential to developing an effective disease prevention program for a hunting dog kennel.

Sanitation

The cleanliness of the kennel has a direct effect on the prevalence of disease in the facility. Owners and trainers often ask, "What disinfectant should I use?" Kennel sanitation is not that simple, however. An overall plan should be designed that allows the kennel to house the lowest number of disease agents possible and this means more than the purchase of a certain antimicrobial agent.

Effective disinfection and parasite control is nearly impossible in kennels with dirt flooring.[1] Grass surfaced kennels are nearly as difficult to sanitize unless a rotational program where dogs are moved from paddock to paddock on a regular basis is instituted. Gravel runs are modest in cost and allow reasonably good sanitation. In my experience, it is difficult to maintain the kennels in a clean manner without removing some of the gravel each day. This does require periodic addition of new gravel to the kennel and will increase overall costs and labor. Dogs invariably dig in the graveled surface, creating ground depressions that hold rain water. Chemical disinfection is very difficult in gravel runs because of the presence of organic matter. Most disinfectants are not effective in the presence of soil, stool remnants, and other organic substances. Gravel can be an acceptable surface, primarily in hunting dog kennels containing a small number of dogs, but only if stools are scrupulously removed manually and weeds kept under control.

Concrete is the most popular kennel surface in hunting dog kennels. Despite the initial installation expense, concrete pens pay long-term dividends by making disease control easier. Care should be taken to repair cracks in the kennel surface when they first appear since they can harbor disease agents if left to deteriorate. A gradually sloped surface and barriers between individual runs helps ease daily cleaning and avoids the spread of disease agents between pens.

Puppies and small breeds, like Beagles, are commonly housed in wire-bottomed facilities. These kennels do aid in sanitation as droppings fall through the wire flooring and overall sanitation of the unit is straightforward. Very heavy gauge wire or expanded metal should be utilized as the flooring surface to prevent sagging; a sagging wire floor makes uncomfortable footing for the dogs. Dogs housed in wire-bottomed, off-ground kennels should receive daily exercise in a surrounding fenced yard.

Regardless of design, all kennels should be dry and sheltered from prevailing winds.[1] No dampness or chilling should be allowed as these conditions increase the incidence of gastrointestinal and respiratory disease. Crowding should be avoided. Runs should be cleaned and disinfected daily. Steam cleaning is an excellent adjunct to this daily cleaning.[1] See ***Table 1*** for a quick review of practices for good environmental management in kennels.

Breeding Facilities

These operations normally have a stable population of adult breeding animals and a transient group of youngsters. Isolation of newcomers is important and, ideally, will last for 30 days. Testing for canine brucellosis should be done on all new breeding dogs before they leave their home kennel and a second test should be performed 30 days later. Facilities for whelping should be carefully designed to optimize the process.

Training Facilities

Training facilities staffed by professional trainers should also isolate new dogs, but the desire to get the dog's training started may make this isolation difficult. Trainers should be aggressive in requiring in-depth veterinary examinations, including canine brucellosis testing, on dogs prior to their arrival at the kennel. Since many competitive dogs end their careers

Table 1.

GENERAL PRINCIPLES OF ENVIRONMENTAL MANAGEMENT IN KENNELS[1]
1. A regular cleaning and disinfecting schedule should be adopted.
2. Waste material should be removed prior to disinfection.
3. Strict adherence to label cautions on disinfectants should be standard.
4. Hot water increases the effectiveness of cleaning and disinfection.
5. Bedding should be changed frequently to keep it clean and dry.
6. Food should be stored in containers with tight fitting lids.
7. Stool removed from the kennel should be disposed of away from the kennel.
8. Watering systems, heating and cooling apparatus should be kept in good working order.
9. Stored equipment, weeds, and debris should not be allowed to accumulate around the kennel setting.

in a breeding program, the protection against neighboring with a dog spreading canine brucellosis or other diseases in crucial.

Items like training dummies check cords, trained-retrieve dowels, electronic training collars, and above all, the trainer's truck should be cleaned and disinfected on a regular basis.

Household Kennels

While not susceptible to the hazards of crowding and the regular arrival of new dogs, hunting dogs that live in the house should receive the benefits of a regular preventive program to avoid disease, as well. Outside facilities for the dogs should allow secure exercise, an appropriate area for lounging, and an area to get away from human visitors during entertaining within the home. Owners of hunting dogs kept within the home have the luxury of close observation of the dogs each day so signs of disease should be noticed promptly.

NUTRITION

Nutrition is a crucial part of the overall health management plan for any kennel. Nutritional "fads" should be avoided.[1] Choose wholesome, nutritious commercial foods that have been scientifically proven to be effective by actual feeding trials as opposed to being formulated to meet minimum nutritional requirements. Foods selected should reflect the lifestage and lifestyle of the dogs in the kennel. Nutritional supplements add considerably to the overall costs of the kennel and, when a well-known commercial diet is utilized that has a reputation for quality, these supplements are unnecessary.

More complete details concerning lifestages and specific nutritional considerations are covered in other chapters in this publication.

PREVENTION OF VIRAL DISEASES

Viruses cause some of the most dread diseases effecting a large kennel. Since viruses do not respond to antibiotics, prevention of these diseases is crucial to the health of the dogs in the breeding and training programs. Excellent vaccines have been developed to prevent the major viral diseases that affect dogs.

Maternal Antibodies

It is fundamental that all kennel managers have an understanding of the protection that is passed from the dam to her puppies and the role it plays in the vaccination process. Newborn pups have an inherent capacity to protect themselves against disease because they normally receive this protection via antibodies* that are acquired from the dam. Some of these antibodies (2–18%) are received in the uterus before birth.[1] These antibodies protect those puppies that for some reason (abandonment, death of dam or rejection) have been deprived of the dam's colostrum (first milk), which contains the majority of defense against disease. While this protection is very important in raising a healthy litter of puppies, it is crucial that all breeders understand that this maternal protection also interferes with protection developed as a result of vaccination.

The amount of protection afforded a litter of puppies is dependent on both the quantity of immunoglobulins the pups receive from the dam, as well as the level of protection the bitch has herself. The level of protection in the bitch can be elevated by vaccination just before mating. Vaccination during pregnancy should be avoided unless the local veterinarian recommends it.

Theoretically, one could measure the level of antibodies in each puppy and, once the level of protection decreased to the point it would not interfere with the vaccination, a single dose of vaccine would protect the puppy. In reality, this testing would be expensive so veterinarians use a series of vaccinations to overcome our inability to look at a puppy and determine the level of maternal protection still present in the puppy's immune system. The idea is to give several vaccinations based on the information shown in ***Table 2*** and thereby protect the pup that has maternal protection and time the last vaccination just after the maternal antibodies disappear and can no longer interfere with the vaccine. Ideally, we use the series of vaccinations to break through the maternal antibody wall before the puppy is exposed to the disease causing viruses.

Vaccines

Vaccinations involve injecting a substance

*Molecules within a living body that protect it against disease.

into the animal that contains antigens* which stimulate the dog's immune system to produce its own antibodies against the disease agent. Vaccines can be categorized in many ways but for the hunting dog kennel owner, the simple breakdown shown in ***Table 3*** is sufficient.

Immunity from vaccinations takes several days to develop, but may last for years. Vaccines utilized in veterinary medicine have a reputation for dependability. Directions for the use of vaccines provided by manufacturers should always be followed closely. Splitting doses between littermates should be avoided. Accurate records should be maintained at the kennel as to vaccination intervals, serial numbers of vaccines used, and vaccination injection sites. Animals vaccinated by the kennel veterinarian normally have these records maintained at the doctor's office.

Table 2. *Effect of maternal immunity on vaccinations for certain diseases*[2]

	MINIMUM AGE TO BEGIN VACCINATIONS (WEEKS)		
	No Colostrum	Received Colostrum	End Vaccinations
Canine Distemper	2-3	6	12-14
Infectious Canine Hepatitis	2-3	6	12
Canine Parvo Virus	5	6-9	12-20*

*12 weeks with high-titer, low-passage vaccines; other vaccines 20 weeks.

Table 3. *Categories of vaccines*

MODIFIED LIVE VACCINES	INACTIVATED VACCINES
• Rapid protection • Prolonged protection • Lower amount of antigen needed • Single dose can protect • More likely to overcome maternal protection • Certain types can be given in nose or mouth • Useful in outbreaks of disease and routine vaccinations • *Examples* - most parvoviral vaccines - intranasal Bordetellosis vaccine - parainfluenza	• Cannot cause disease • Can have increased activity with additives • Stable during storage • Safe in animals with poor immune systems but can have more allergic reactions • Shorter immunity • Must be injected • Useful in pregnant or debilitated animals • *Examples* - Lyme vaccine - coronavirus vaccine - injectable Bordetellosis vaccine - leptospirosis - rabies

Different vaccine products should **never** be mixed to produce a combination of vaccines at the kennel. The combination vaccines provided by manufacturers have been licensed as a result of stringent testing to insure compatibility.

Core Vaccinations

Canine Distemper/Measles Vaccine. While puppies cannot get human measles, the virus that causes this disease is closely related to the canine distemper (CD) virus. As a result, young puppies (6–9 weeks) can often gain an immune response despite the presence of maternal protection. Only about 50% of puppies can stimulate immunity from a standard distemper vaccination at age 6 weeks[2] so measles vaccination may offer better protection to young puppies. Measles vaccine should never be given to female puppies older than 9 weeks. After that age, the pup will stimulate long lasting antibodies which, when passed on to her puppies in her first litter, will interfere with those pups' measles vaccination. Besides, by age 9 weeks, the maternal immunity is beginning to wane and standard CD vaccines should begin to protect the puppy.

All puppies should receive at least two vaccinations against CD.[2] Puppies less than 12 weeks of age should receive three vaccinations 2–4 weeks apart. In general, if exposure to CD is low, adults should be revaccinated every other year because protection may wane if vaccinations are not repeated.[2]

Infectious Canine Hepatitis. Since vaccination for infectious canine hepatitis (ICH) is normally included in the vaccine for CD, the guidelines are similar as to timing. Vaccination has brought about a notable decrease in this disease, which was once widespread. The term canine adenovirus type-1 (CAV-1) is now com-

*Molecules that stimulate antibody production.

monly used for the ICH virus because it is closely related to adenovirus type-2 (CAV-2) which causes an upper respiratory condition. Vaccines may be labeled CAV-1 and CAV-2 instead of ICH. CAV-2 vaccines also may protect against ICH.

CAV-1 vaccine has the ability to produce a condition called "blue-eye" in a small percentage of dogs while CAV-2 vaccine normally does not cause this condition.

Kennel Cough. Canine infectious tracheobronchitis (CIT) is caused by a number of viruses and bacteria. CAV-2, CD, parainfluenza virus, and *Bordetella bronchiseptica*, a bacterium, are among the common culprits.

Vaccines for kennel cough are available in injectable form and in-the-nose forms. Injectable products do not normally produce immunity until 2–3 weeks after the second vaccination.[2] Early injectable Bordetella vaccines caused pain and swelling or even abscesses. Newer injectable Bordetella vaccines are more purified and these side effects are uncommon. But, the purification process has resulted in shorter duration of immunity. Still, the convenience of administering the vaccine as an injection in combination with other vaccines is significant.

In-the-nose (intranasal) vaccines are available for both parainfluenza and Bordetella and they can provide immunity as quickly as 72 hours after administration.[2] However, dogs often resist dropping vaccine into their nose and vaccinating an entire kennel of hunting dogs with these vaccines can be time-consuming.

Ideally, in a sporting dog kennel, dogs will be given two injectable vaccines as part of their puppy vaccinations. Dogs that are at risk (regular exposure to other dogs at events, such as field trials) should receive an intranasal booster 21 days before the event. This interval allows any mild side effects from the intranasal dosing to subside before the competition. Dogs that are not attending events have lower risk and should be sufficiently protected by annual injectable boosters to prevent kennel cough.

Canine Parvoviral Enteritis (CPV). The mention of this viral disease strikes fear in the heart of experienced breeders because of the devastating effects it had on kennels in the 1970's and 1980's. Vaccination for this condition is essential in the sporting dog kennel because not only is the disease contagious, the organism is quite stable in the kennel environment. This means that 95% of the dogs in the kennel must be immune to the disease to prevent its spread.[2]

CPV is primarily a disease of young dogs (< 2 years of age). Most of the vaccination effort should be focused on weaned puppies. Annual vaccination of adult dogs may not be necessary but since CPV vaccine is contained in vaccines for CD and kennel cough, it is often included for convenience. Vaccination protocols vary from veterinarian to veterinarian and kennel to kennel. Local veterinarians are the best resource for recommendations on vaccination schedules but a typical timetable for a hunting dog kennel would be vaccinating every 3–4 weeks beginning at age 6 weeks and ending at age 20 weeks. Newer, more potent vaccines may be able to override the maternal protection at age 12 weeks, but puppies born to bitches that have high immunity can have this protection out to 20 weeks and it can interfere with the vaccine's performance.

Rabies. Some states allow owners to vaccinate their own dogs for rabies, but it is a better policy to allow the local veterinarian to perform this vaccination. Since legal issues and human health matters are involved, using a professional can avoid conflicts if a dog bites a human. Rabies vaccines are among the most effective products in veterinary medicine and have been very effective in reducing the occurrence of this dread disease. All rabies vaccines approved in the United States are inactivated, but these products provide protection that is comparable to modified live vaccines.

Other Vaccinations

Canine Coronaviral (CCV) Infections. The incidence and severity of CCV infections varies with locale. First isolated from military dogs in Germany, the disease can cause vomiting and diarrhea. While CCV has been isolated from dogs with these symptoms in several countries, the condition remains controversial among veterinary virologists. Local veterinarians will have the best information as to incidence in the kennel community.

While the disease has a reputation for mild symptoms, deaths due to CCV have been reported in young puppies. Unlike CPV, the agent that causes CCV is fragile and easily disinfected from the kennel. A vaccine is available and should be used if the kennel veterinarian recommends its use.

Leptospirosis. Canine leptospirosis is a changing disease. Prior to the 1990's, the vast majority of cases of leptospirosis in the dog were caused by two "serovars"*: *icterheaemorrhagiae* and *canicola*. Vaccines used to protect dogs against this disease were made using only these two serovars and have been available for over 30 years. Recent published reports show that two new serovars, *grippotyphosa* and *pomona*, have emerged as significant causes of canine leptospirosis.[4]

If the kennel veterinarian recommends vaccination for leptospirosis, it is important that the new serovars are included in the vaccinations.

Lyme Disease. The dominant symptom of this condition in dogs is a recurrent lameness due to arthritis. Some dogs stop eating and show depression as a result of Lyme disease. Heart, brain, and kidney involvement has also been reported.

The causative agent of the disease, *Borrelia burgdorferi*, is found worldwide but normally in pockets called "endemic areas". In the United States, more than 90% of the cases are found in the northeast, the upper Mississippi region, California, and some southern states. The disease is spread by deer ticks, so dogs that are exposed to ticks are more susceptible to Lyme disease.

Prevention of Lyme disease involves protection of the dog from tick infestation and/or vaccination. The kennel veterinarian will know the best method and will be able to advise on the best choice of vaccine types.

General Observations About Vaccinations in the Kennel Setting

It is common for trainers and breeders to immunize dogs in their kennel themselves with vaccine they have purchased directly. There is nothing catagorically wrong with this but there are disadvantages. For example, current recommendations for vaccinations require a flexible vaccine choice. Mail ordered vaccines do not offer this flexibility or, at the least, require a substantial inventory of vaccine types in the kennel. Secondly, the routine use of "seven-way" vaccines may not only be financially wasteful but may have deleterious effects on the dogs. Another approach involves recruiting the kennel veterinarian to design a comprehensive vaccination protocol for the kennel and utilize vaccines with more specific uses than the typical product with several protective agents in the vial. This system leads to optimal protection, minimal side-effects, and economy.

PARASITE CONTROL

Internal Parasites

Parasites of the intestinal tract are not normally a serious problem in sporting dog kennels because greatly improved deworming products, plus modern sanitation methods have vastly decreased the incidence of parasitism. Still, owners and trainers should have some knowledge of intestinal parasites and their treatment to insure continued controlled of worms in their dogs.

Roundworms

Roundworm infections can occur without symptoms in adult dogs but cause classic signs in puppies. Ill-thrift, potbellies, poor hair coats, and retarded growth are all signs of roundworm infection in puppies. Certain stages of the roundworm can migrate to the lungs and cause a soft cough. If large quantities are present, intestinal blockage can occur after treatment. As a result, early and frequent treatment should be done on all puppies. In addition, the dog roundworm can infect humans with serious results. This is another reason for effective treatment of puppies. The drugs of choice are piperazine or pyrantel pamoate (Nemix®). Treatment should begin at 3 weeks of age and be repeated every 3 weeks until the puppy is 3 months of age.[3]

Hookworms

This is one of the most important parasites of young hunting and field trial dogs. Symptoms are primarily related to anemia from blood loss due to the parasites. Treatments of choice are milbemycin oxime (Interceptor®) and fenbendazole (Panacur®; Hoest).

Strongyloides

This is a rare parasite in modern sporting dog kennels because it is dependent on poor sanitation for survival in a kennel. Signs are

*Serovar is a variety or type of disease agent that is closely related to other disease causing agents.

diarrhea, coughing, and listlessness. The coughing is due to the migration of the parasites to the lungs. Prevention aims at improved sanitation and removal of moist areas within the kennel environment where the parasite can thrive. Treatment varies but ivermectin is mentioned in the veterinary literature as effective.[3]

Whipworms

These parasites can be very important in sporting dog kennels. Signs of blood-tinged feces, straining to defecate, profuse watery diarrhea, and weight loss can mean whipworms. Diagnosis by the kennel veterinarian may require several laboratory examinations of the feces for the football-shaped egg. The treatment of choice is fenbendazole (Panacur®; Hoest) or milbemycin oxime (Interceptor®) based on the kennel veterinarian's recommendation.

Whipworm eggs persist in many kennels and may lead to persistent reinfection. Diligent sanitation is crucial in preventing this situation. Since the reinfection time (prepatent period) for whipworms is rather long (10 weeks), routine deworming for whipworms at 8 week intervals for 12 months will gradually eradicate the parasite from most kennels.[3]

Coccidia

In the past, the dog coccidia organism was classified along with those of poultry, cattle and other livestock. Recently, the dog parasite has been reclassified to include several similar parasites (*Cryptosporidia, Sarcocystidae, Hammondia, Toxoplasma, Besnoitia,* and *Cystoisospora*). These parasites vary in their ability to cause disease and can be difficult to differentiate in a veterinary clinic lab. The nutritional status of the puppy has an effect on the ability of these organisms to cause disease. In puppies with marginal nutritional status, a suppressed immune system, or other diseases, coccidiosis can be serious. In puppies that are healthy and on a high plane of nutrition, coccidiosis can occur with no signs and is often self-limiting. In cases that require medication, trimethoprim-sulfa is a popular treatment.[3]

Giardia

Giardia infections occur occasionally in large sporting dog kennels and often require aggressive treatment. Diagnosis can also be difficult because the organisms are difficult to find in the stool. Multiple samples may be required to document Giardia infections. Treatment depends on the severity of the case and may even require IV fluid therapy. Treatment for the actual infection can be accomplished with fenbendazole (Panacur®; Hoest).[3]

CONCLUSION

Part of the gratification of owning well-bred and well-trained sporting dogs comes from giving them optimal care. A team of the kennel veterinarian, kennel staff, and the owner/trainer must work together to develop comprehensive, effective, and economical programs that support a healthy group of dogs. Then, not only are the dogs more likely to gain the accolades they deserve in competition, but the people who care for them can share in the enjoyment of seeing well-cared for dogs perform as a result of excellent facilities, veterinary care, and nutrition.

REFERENCES

1. Lawler DF. Prevention and management of infection in kennels. In: *Infectious Diseases of the Dog and Cat*. 2nd ed. Philadelphia: WB Saunders. 1990; 706-709.
2. Green CE. Immunoprophylaxis and immunotherapy. In: *Infectious Diseases of the Dog and Cat*. 2nd ed. Philadelphia: WB Saunders. 1990; 719-731.
3. Guilford WG, Strombeck DR. Gastrointestinal tract infections, parasites, and toxicoses. In: *Strombeck's Small Animal Gastroenterology*, 3rd ed. Philadelphia: WB Saunders, 1996; 425-428.
4. Wohl JS. Canine leptospirosis. *Compendium* Nov. 1996.

Martin Coffman, DVM

Dr. Coffman is a 1970 graduate of the College of Veterinary Medicine at Auburn University. He did his undergraduate work at the University of Tennessee in Knoxville. After 30 years in private veterinary practice, Dr. Coffman is currently the Manager of Technical Communications for The Iams Company's Research and Development Division. He is president-elect of the American Canine Sports Medicine Association, a member of the Society for Theriogenology, and Auburn's Sports Medicine Advisory Panel. He owns Briarmaster Kennels and competes in Beagle field trials nationwide. Dr. Coffman lectures extensively to clubs and organizations throughout the U.S.

Weaning the Field Bred Puppy

Russ L. Kelley, MS

INTRODUCTION

The rearing of replacement puppies is a crucial part of any sporting dog breeding program. After carefully planned matings, the whelping process, the nurturing of the newborns, the weaning process can be very gratifying as the new pups acquire a personality and begin to eat on their own.

Fortunately for breeders, the weaning process is a naturally-occurring event. Regardless of whether puppies are reared by the bitch or hand raised, the process will be similar although there will be slight differences in the timing. The weaning process can begin anytime after three weeks of age when the puppies are able to stand and walk. However, the 3-week timeframe is usually implemented only on hand-raised puppies or litters where the bitch is experiencing problems with milk production.

A more practical time to begin the weaning process in bitch-reared litters would normally be around 4 weeks of age. By this time, the puppies will be more active and have higher caloric needs, thus a greater desire to utilize an alternative to their dam's milk. The process itself is not difficult, but there are a few management practices that will make it easier on the puppies, the bitch, and the breeder.

THE WEANING PROCESS

As mentioned earlier, the weaning process is natural and will occur with or without breeder intervention. Wild *canid* bitches stimulate the weaning behavior by regurgitating partially digested meals after returning from a successful hunt. However, most (but not all) domesticated bitches appear to have lost that instinct or simply do not perceive the need to provide this stimulation under modern management practices.

Breeders have long mimicked this behavior by offering a gruel to the puppies. This gruel can be prepared by mixing some of the bitch's formula (preferably a performance or growth formula) with warm water. Alternatively, there are specially designed formulas for the weaning process. One such formula, Eukanuba® Weaning Formula, is a nutritionally balanced, calorie-dense formula that has been pre-ground to allow easy mixing with warm water.

Initially, the gruel should be semi-liquid (65–70% water) so the puppies can lap the mixture. The percentage of solids can be increased as the puppies grow more accustomed to the routine. It is also helpful to begin to add a few whole kibbles to the gruel after a week or so. This will help the puppies become familiar with the food texture and by 6 to 7 weeks of age, most puppies will freely consume dry kibbles.

MANAGING THE WEANING PROCESS

There are no hard rules for managing the weaning process; some litters will be easy while some will be challenging. There are a few steps that will help in most cases. First, always remove the bitch from the whelping area an hour or so before offering the puppies the gruel mixture. This will help ensure that the puppies are hungry and will keep the bitch from eating the mixture. Secondly, don't get too concerned with the mess. The first few days, the puppies will walk in, lie in, play in, and actually might eat some of the gruel. They will get better with each passing day. The bitch will clean the puppies as she has done since their birth when she returns.

The type of pan will also contribute to the extent of the "mess". A large muffin pan works well for most puppies. The muffin bowls will help contain the gruel, which will help the puppies when lapping. Lastly, use the puppies' actions as a progression guide. Don't be too eager to change the gruel mixture if all the puppies have

Table. *Recommendations for weaning puppies*

AGE OF PUPPIES	RECOMMENDATIONS
26–30 days	Begin offering a wet mixture (65–70% water) to the puppies two to three times daily. Eukanuba® Weaning Formula has been shown to work well in this application, but a growth or performance formula can be used. If a growth formula or performance formula is going to be used, the kibbles should be soaked for at least 10 minutes and mashed to a gruel consistency.
31–34 days	Percentage of solids can be increased to around 40% (60% water) and the number of offerings should increased to four times daily. As before, if a growth formula or performance formula is going to be used, the kibbles should be soaked for at least 10 minutes, but leave some of the kibbles whole. Also begin to offer puppies clean fresh water in a separate container. Their main supply of water to this point has been from the bitch's milk.
35–38 days	Percentage of solids can be increased to around 45% (55% water) and the number of offerings should increased to four times daily. As before, if a growth formula or performance formula is going to be used, the kibbles should be soaked for at least 10 minutes. It should not be necessary to mash the kibbles from this point forward. Also start adding a few dry kibbles to the mixture. A constant supply of clean fresh water should be available to the puppies at all times from this point forward.
39–42 days	Transition puppies to a mixture of 50% gruel (45% solids) and 50% dry kibbles. If puppies will require a specialized formula during their growth phase, such as Eukanuba® Large Breed Puppy Formula, it is helpful to start introducing them to that formula at this time.
43+ days	Puppies can be completely weaned at the breeders discretion. However the breeder should ensure that each puppy is gaining weight and is maintaining hydration. Some puppies may need a few extra days of training. If puppies have not been introduced to and transitioned onto the growth formula specifically designed for their mature body size yet, it should be done at this time.

not mastered the routine. The information in the ***Table*** provides a good rule of thumb for weaning.

NUTRITION FOR THE DAM

The suggestions above will help with the puppies, but what about the bitch? It is critical that the bitch also be managed through the weaning process. We have already mentioned one key point earlier; remove the bitch for an hour or so prior to offering the puppies their gruel mixture. Most bitches will welcome a short break from the litter by week 4 of lactation. Around the fifth week of lactation, the breeder will also need to begin decreasing the bitch's caloric intake to around 250% of maintenance with further decreases every week thereafter until the puppies are completely weaned. A good target would be 125% of maintenance for the bitch by week 8 post-whelping. This decrease will help reduce the milk production by the bitch, thus encouraging the puppies to seek an alternative nutrient source and making it easier to dry off (stop milk production) the bitch after weaning.

Once the breeder has decided to completely wean the litter, keep the bitch separated from the puppies for at least a 3-day period. On a closing note, if for some reason the litter has to be weaned abruptly, it is a good idea to drastically reduce the bitch's intake for the first 24 hours and then slowly bring her back up to maintenance levels over 3 to 4 days. This will greatly reduce her milk production and hopefully avoid any complications with her mammary glands.

CONCLUSION

As the bitch spends less time with the puppies, breeders need to spend more time. This is a time for bonding and introducing puppies to the human world. Extra effort during the weaning process and in the weeks afterward will pay dividends as the pups mature into bold, easily trained hunting or field trial dogs.

Russ L. Kelley, MS

Russ Kelley is an alumnus of Auburn University where he received his BS in Animal Science in 1988 and his MS in Animal Science in 1998. He served on the staff of Auburn University from 1992 to 1997 as a Research Specialist in the area of Growth & Developmental Biology for the Department of Animal & Dairy Sciences. While at Auburn University, research efforts focused on myogenic regulatory mechanisms during embryonic and neonatal development of domestic livestock. In 1997, Mr. Kelley accepted a position with The Iams Company as a Research Associate in the Research and Development Division. He is currently a Research Scientist and as a member of the Strategic Research team, he provides assistance with research efforts in the areas of reproduction and neonatal nutrition. Mr. Kelley has published several scientific papers and abstracts in peer-reviewed journals on regulatory influences of animal growth and development.

Optimal Nutrition for the Growing Retriever and Upland Dog

Allan J. Lepine, PhD

INTRODUCTION

Growth can be defined as a process of tissue enlargement for the specific purpose of increasing body size. Canine growth, and in particular skeletal development, is unique relative to other species in that the range of mature body size (and therefore growth rate) and conformation across breed is quite dramatic. Just in hunting breeds—from Border Terriers and Beagles to English Pointers and Treeing Walkers—the diversity is impressive. These conformational distinctions result from the varied functions for which the individual breeds were originally intended, such as retrieving, pointing game, tracking, treeing game, running hounds, or flushing. The breed variation also reflects the type of game which the dog was bred to apprehend.

Evidence for this is readily apparent in the extreme when a breed such as the Dachshund, which was bred to hunt burrowing rodents, is contrasted to the aerodynamic conformation of the Greyhound or the hound conformation of a Foxhound. It is precisely this genetic diversity that makes it difficult to provide generalized recommendations regarding growth management of the dog, but instead mandates that breed characteristics be considered. It is therefore inappropriate to consider increased size alone as the criterion against which the appropriateness of growth should be judged. Rather, the development of a structurally sound field dog, able to effectively withstand the stresses placed upon it over a lifetime of hunting or field trial competition, is the true measure of success.

Of particular interest with respect to growth are the large breeds, which include many of the dogs used for sporting purposes such as retrievers, pointers, setters, and hounds. It is readily apparent that for some breeds, genetic selection has been directed in part towards an increasing mature body size. It is precisely the large mature body size and the inherent ability to grow very rapidly that places these dogs at increased risk of developing skeletal disease during growth. While an increased genetic potential for growth rate is not in itself detrimental to the large sporting dog, management practices that allow growth rate to be maximized can result in negative consequences.

It is well documented that the incidence of skeletal disease, including osteochondroses, hypertrophic osteodystrophy, and hip dysplasia, is markedly increased in the growing large breed dog if management practices are such that this maximal rate of growth is realized. The predominant management consideration impacting growth rate, and ultimately skeletal disease, is nutritional support; that is, how much and what is fed to the growing puppy. Although many nutritional considerations have been implicated in skeletal disease in the growing large breed dog, three predominant factors—the dietary concentrations of protein, energy, and calcium —are most often indicted.

The development of practical nutritional recommendations and management practices designed to reduce the incidence of skeletal disease in the growing sporting breed dog requires definition of the predominant diseases, a review of existing information regarding potential nutritional factors, and the establishment and conduct of innovative research designed to establish optimal nutritional strategies.

PREDOMINANT GROWTH-RELATED DISEASES

Hypertrophic Osteodystrophy

It has been reported that several sporting dog breeds, including the Irish Setter, Weimaraner, German Shorthaired Pointer, and Labrador Retriever are disproportionately predisposed to hypertrophic osteodystrophy (HOD). This metabolic bone disease affects the dog during the phase of rapid growth (3 to 6 months of age) and is characterized by failure to eat, fever, lameness, and painful swelling of the limbs near joints. The grossly apparent swellings are the result of a fibrous thickening of the lining around the bone, accompanied by new bone formation. Commonly affected are the long bones below the elbow and stifle (knee); however, all long bones can be affected.

Osteochondrosis (OCD)

The acute pain, swelling, and lameness of osteochondrosis (OCD) is most commonly observed in the shoulder, elbow, hock, and stifle of the growing large breed dog. Sporting dogs reported to be particularly susceptible to OCD include the Labrador and Golden Retrievers. Although the cause is considered to be multifactorial, the damaged cartilage is reported to result from a weak bone under the cartilage that is unable to provide adequate support for the joint cartilage. Secondary disturbances then occur in the function and metabolism of the cartilage-forming cells in the developing joint surface. In serious cases, a small divot-like depression may form on the joint cartilage surface and a tiny flap may develop over the cartilage defect. Most cases of OCD of the shoulder respond well to surgery.

Canine Hip Dysplasia

Canine hip dysplasia can develop during growth as a result of a disparity between the strength of the muscles, tendons, and ligaments supporting the hip joint and the increasing biomechanical forces associated with weight gain. This lack of strength, plus the rapid weight gain, can result in a loss of "fit" between the head of the thigh bone (femur) and the surfaces of the hip socket. This subluxation produces remodeling of the joint including a shallowing of the hip socket, a flattening of the femoral head, and eventually, osteoathritis. Chronically affected dogs may have no clinical signs or may indicate only mild discomfort, particularly following periods of relatively intense exercise. In contrast, severe hip dysplasia produces marked lameness, pain, abnormal gait, reluctance to rise, and atrophy of the thigh muscles. Hip dysplasia has been reported in all breeds and appears prevalent in retrievers and setters. It can end the career of promising hunting and field trial dogs.

EFFECTS OF NUTRITION ON SKELETAL DISEASES

It is readily apparent that all three of these developmental diseases—hypertrophic osteodystrophy, osteochondrosis, and hip dysplasia—have a genetic component influencing their prevalence throughout the dog population. The propensity for these diseases in the large breed dog and the frequent association with specific breeds involved in sporting activities raises awareness among owners and trainers regarding the nutritional factors affecting skeletal health. The most commonly implicated nutritional factors in skeletal disease in the growing large breed dog are dietary protein concentration, the energy density of the diet (calorie content), and the amount of calcium consumed. A systematic consideration of the impact of these nutrients on skeletal disease in the large breed puppy is necessary before establishing scientifically based nutritional recommendations that are designed to maximize a positive outcome during growth.

Protein

One common misconception is that commercially prepared premium dog foods contain excessive quantities of protein that may be detrimental to the growing larger breed dog by supporting too rapid a growth rate. This is not confirmed by controlled research, and fortunately, support for this misconception is diminishing. Much of the research presented in this chapter has been conducted in the growing Great Dane. Although this is obviously a non-sporting breed, its use as a model for other large breeds, including the sporting breeds, is considered very appropriate due to its extremely rapid growth rate.

Growing Great Danes consuming diets with identical calorie content, but providing a broad range of dietary protein (31.6%, 23.1% or

14.6% protein), from weaning to 18 weeks displayed no evidence of protein effect on calcium metabolism or skeletal development.[1,2] Changes consistent with disturbed bone development were observed to be equally distributed across diet groups, indicating no specific effect of dietary protein concentration. Although the high-protein diet did not promote any detectable negative effect on skeletal development, the low-protein diet was considered only marginally sufficient for the growing Great Dane in these diets, providing approximately 3,600 kcal metabolizable energy (ME)/kg of diet.

Body weight was significantly reduced in the dogs consuming the low-protein (14.6%) diet, relative to those fed the high-protein diet (31.6%) at 13 and 15 weeks of age, while plasma albumin concentrations, which are important for good overall health, remained with the low-protein diet throughout the study. This demonstrates that the protein concentration typically incorporated into premium dog foods does not increase the manifestation of skeletal disease in the growing large breed dog, but that it is possible to reduce the dietary protein level to a point where the provision of nutrients is marginal. When evaluating the dietary protein concentration, balance of the protein and energy is the most important concern in commercial diets for growing large breed dogs.

Free-choice Feeding

The belief that an elevated dietary protein concentration can exacerbate skeletal disease in the growing dog is more likely due to a parallel increase in dietary energy (calories), rather than due to a response to dietary protein per se. Free choice feeding to growing Great Danes promoted a dramatic increase in the incidence of skeletal disease, compared to the same diet at 66% of intake on self-feeders.[3] Dammrich[4] provided further support for this growth rate response by feeding Great Danes with either free choice or restricted (60–70% of free choice) intake from weaning through 6 months of age. Maximal growth with free choice intake resulted in bone under the cartilage that was less dense and weaker per unit area. The resulting bone loss and biomechanically weak bone could not adequately support the joint cartilage. In addition, the increased growth rate with free choice feeding more rapidly subjected the joint surface to stresses due to increased body weight. In other words, the bone under the cartilage was weaker and the puppies weighed more when fed free choice, that is, consumed more calories.

Clearly, a high level of energy intake can promote an excessive rate of growth in the large breed dog and increase the potential for the development of skeletal disease. It is essential to manage the rate of growth in order to minimize the incidence of skeletal disease.

Calcium

In contrast to dietary protein, dietary calcium concentration can have a significant effect on the development of skeletal diseases in the growing large breed dog. Hazewinkel and coworkers[5] and Goedegebuure and Hazewinkel[6] fed growing Great Danes a diet containing either a typical calcium concentration (1.10% calcium and 0.90% phosphorus) or a high calcium concentration (3.30% calcium and 0.90% phosphorus) from weaning through 6 months of age. The effect of the high-calcium diet on skeletal development and skeletal disease (increased radiographic irregularities, more osteochondritic lesions) clearly demonstrated the negative impact of excess dietary calcium on skeletal health of the growing large breed dog.

This conclusion is further supported by the finding that the growing large breed dog is ineffective in reducing intestinal calcium absorption in the presence of an elevated dietary calcium concentration, since considerable passive transport of calcium takes place.[7] The large breed puppy is therefore less able to protect itself and its developing bones and joints from a chronic high dietary calcium intake. In contrast, the active component of intestinal calcium transport can be very effectively increased in the large breed puppy, such that more than 90% of intestinal calcium can be absorbed when the dietary calcium concentration is low. Therefore, these puppies are more adequately protected against inadequate calcium consumption than against excessive calcium consumption. More simply stated, puppies can adjust their absorption of calcium if the dietary level is low, and absorb a higher percentage of the calcium in the food, but they cannot protect themselves against a dietary level of the mineral that is too high.

CURRENT NUTRITION RESEARCH

Recent research, again using the growing Great Dane as a model of rapid growth, has defined an appropriate dietary calcium and phosphorus concentration as provided in a food with moderately reduced energy density. In brief, 36 growing Great Danes were assigned before weaning to three diets, differing only in calcium and phosphorus concentration as follows: 0.48% calcium and 0.40% phosphorus (low-calcium diet); 0.80% calcium and 0.67% phosphorus (medium-calcium diet); and 2.70% calcium and 2.20% phosphorus (high-calcium diet). These levels of calcium and phosphorus were selected to allow evaluation of the theory that balanced calcium and phosphorus concentrations lower than found in typical premium growth diets (eg, 1.20% calcium and 1.00% phosphorus) would enhance skeletal health of the growing large breed dog when provided in a diet with reduced calories.

A diet containing a reduced energy density, relative to a typical growth diet, is necessary to assist in the management of growth rate and thereby decrease and prolong the slope of the growth curve. This would benefit the typical growing hound, setter, or retriever because of the previous research documenting the side-effects of a growth rate that is too rapid. The reduced energy density was achieved in all three diets by the inclusion of 14% fat, compared to 20–21% fat in the typical premium growth food. Dietary protein concentration was also lowered to 26% in all diets to maintain an appropriate dietary protein-to-energy ratio. The three treatment diets were provided to the growing Great Danes during weaning through 18 months of age. The results published to date are the foundation for nutritional recommendations specifically designed to meet the needs of the growing large breed dog.

From these studies, Lauten and coworkers[8] and Goodman and coworkers[9] reported that the growth rate of Great Danes consuming a diet providing 26% protein and 14% fat was influenced substantially by dietary calcium and phosphorus concentration. The medium-calcium diet promoted more rapid growth compared to either the low- or high-calcium diets. However, the growth rates in all three treatment groups were less than the genetic potential, due to the reduced energy density of the diet relative to typical premium growth foods and to feeding management (time-restricted feeding). Dogs fed the medium- and high-calcium diets achieved the same mature size, while dogs fed the low-calcium diet tended to remain smaller throughout growth, indicative of a potential mineral limitation in that diet. Measurement of the length of the humerus, radius, femur, and tibia and circumference of the thigh and radius also confirmed this diet response.[9] The effect on growth rate suggests that the medium-calcium diet (0.80% calcium and 0.67% phosphorus) most effectively provided for the specific nutritional requirements of the growing Great Dane when growth rate is managed with a 26% protein, 14% fat diet.

Overall body conformation was evaluated and reported to be consistently poorer for growing Great Danes fed the high-calcium diet compared to those fed either the medium- or low-calcium diet.[9] Similarly, 86% of all lameness cases observed during the study were associated with the high-calcium diet.[11] Furthermore, all cases of HOD were observed in dogs consuming high calcium.[9] Likewise, repeated gait analyses conducted throughout growth (at 4, 6, 8, 12, and 18 months of age) on 4 dogs in each diet group indicated that all of the dogs consuming the low- or high-calcium diets had some evidence of gait abnormality.[12] In contrast, three of the four dogs fed the medium-calcium diet had satisfactory gait characteristics at all exams. Conformation and gait of the Great Dane, when evaluated throughout growth, are positively influenced by the consumption of 0.80% calcium and 0.67% phosphorus in an appropriately reduced energy density matrix. The medium-calcium diet provided appropriate growth while minimizing skeletal abnormalities.

FEEDING RECOMMENDATIONS

Current research clearly documents that the skeletal development of the growing large breed dog is best supported by feeding a diet that contains 26% protein (from high-quality, animal-based sources), 14% fat, 0.80% calcium, and 0.67% phosphorus. Supportive evidence

for this recommendation is both convincing and compelling and is summarized in the ***Table.*** A reduced dietary energy density, relative to typical growth food, provides for easier management of growth rate and results in a moderately slowed growth rate relative to the genetic potential for growth. This will result in the same ultimate mature body size and a skeletal structure that is better able to support the increasing body mass as growth progresses. This is particularly important for larger breeds involved in sporting activities, since the stresses applied to the skeletal system are magnified throughout the career of these dogs, in contrast to more sedentary individuals. Rapid growth rate and calcium supplementation are to be absolutely avoided with the growing large breed dog. Failure to follow an appropriate, scientifically justified feeding management regimen can result in a less-than-optimal skeletal structure.

The Negatives of Supplementing

Although dietary calcium is most often provided in excess of that needed by the growing large breed puppy, that is not always the case. A puppy raised on a homemade diet that contains high amounts of fresh meat may, in contrast, be receiving an inadequate supply of calcium. Feeding mostly meat, without an appropriate commercially prepared growth diet formulated specifically to meet the needs of the growing large breed puppy as previously defined, can easily result in dietary calcium concentrations below 0.48% calcium, which itself has been shown to produce suboptimal skeletal development.

Supplementing a high-meat diet with calcium to an appropriate concentration (0.80%), although possible, is not the recommended strategy. Supplementation requires an accurate analysis of dietary calcium and phosphorus and a very specific addition of calcium to provide not only the needed calcium, but also to ensure that the calcium-to-phosphorus ratio is correct (1.2 to 1). Furthermore, the amount of supplemental calcium required will not remain constant over time since the content of calcium and phosphorus in the base diet will vary depending on the source of meat. It would therefore be extremely difficult, if not impossible, to maintain a constantly correct dietary supply of calcium and correct calcium-to-phosphorus ratio.

CONCLUSION

The large breed growth diet discussed herein would assist in maintaining an appropriate growth rate for Retriever and Upland puppies since the calorie level is moderately reduced, relative to the typical premium growth diet.

Table. *Summary of protein, energy, and calcium effects on skeletal development and nutritional recommendations*

Nutrient	Effect of Nutrient Level on Skeletal Development			Nutritional Recommendation
	Low	Medium	High	
Protein	▼ Growth rate if nutrient deficiency	Normal growth	Normal growth	26%
Energy	▼ Growth rate if nutrient deficiency	Normal growth	▲ Growth rate ▲ Skeletal abnormalities	14%
Calcium	▼ Growth rate ▼ Bone mineral ▼ Bone strength ▲ Gait abnormalities	▲ Bone mineral ▲ Bone strength ▼ Gait abnormalities ▼ HOD Good conformation	▲ Bone mineral ▲ Bone strength ▲ Gait abnormalities ▲ HOD Poor conformation	0.80% (1.2:1 Ca:P ratio)

The recommendation for feeding these growing puppies for optimal skeletal development is therefore the same as for feeding other large breeds that will ultimately be involved in strenuous sporting activities: feed a commercially prepared premium growth food designed to properly support skeletal development through the provision of the correct calcium and phosphorus concentration (lower than in the "typical" puppy food) with a reduced calorie level (along with a normal protein level) designed to manage growth rate.

Feeding a food specifically formulated for rapidly growing Pointers, Setters, Labradors, Chesapeakes, Flat-Coats, Foxhounds, and other hunting breeds that mature at over 50 pounds can result in healthy youngsters with less chance of serious skeletal diseases, such as OCD.

REFERENCES

1. Nap RC, Hazewinkel HAW, Voorhout G, Van Den Brom WE, Goedegebuure SA, Van 'T Klooster ATh. Growth and skeletal development in Great Dane pups fed different levels of protein intake. *J Nutr* 1991; 121:S107-S113.
2. Nap RC, Hazewinkel HAW, Voorhout G, Biewenga WJ, Koeman JP, Goedegebuure SA, van't Klooster ATh. The influence of the dietary protein content on growth in giant breed dogs. *J Vet Comp Ortha Traumatol* 1993; 6:1-8.
3. Hedhammar A, Wu F, Krook L, Schryver HF, Delahunta A, Whalen JP, Kallfez FA, Numez EA, Hintz HF, Sheffy, Ryan GD. Overnutrition and skeletal disease. An experimental study in Great Dane dogs. *Cornell* Vet 1974; 64(Suppl 1): 1-160.
4. Dammrich K. Relationship between nutrition and bone growth in large and giant dogs. *J Nutr* 1991; 121:S114-S121.
5. Hazewinkel HAW, Goedegebuure SA, Poulos PW, Wolvekamp WThC. Influences of chronic calcium excess on the skeletal development of growing Great Danes. *JAVMA* 1985; 21:377-391.
6. Goedegebuure SA, Hazewinkel HAW. Morphological findings in young dogs chronically fed a diet containing excess calcium. *Vet Pathol* 1986; 23:594-605.
7. Hazewinkel HAW, Van Den Brom WE, Van 'T Klooster ATh, Voorhout G, Van Wees A. Calcium metabolism in Great Dane dogs fed diets with various calcium and phosphorus levels. *J Nutr* 1991; 121:S99-S106.
8. Lauten SD, Goodman, SA, Brawner, WR, Cox, NR, Hathcock, JT, Jungst, SB, Kincaid, SA, Montgomery, RA, Rumph, PF, Baker, HJ, Reinhart, GA, Lepine, AJ. Growth and body composition of the large breed puppy as affected by diet. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Volume II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington: Orange Frazer Press, 1998; 3-12.
9. Goodman, SA, Montgomery RD, Fitch, RB, Hathcock, JT, Lauten, SD, Cox, NR, Kincaid, SA, Rumph, PF, Baker, HJ, Lepine, AJ, Reinhart, GA. Serial orthopaedic examinations of growing Great Dane puppies fed three diets varying in calcium and phosphorus. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Volume II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington: Orange Frazer Press, 1998; 63-70.
10. Lauten SD, Brawner Jr WR, Goodman SA, Lepine AJ, Reinhart GA, Baker HJ. Dual energy x-ray absorptiometry measurement if body composition and skeletal development in giant breed dogs fed diets differing in calcium and phosphorus. *FASEB J* 1997; 11:A388.
11. Brawner W. Imaging techniques evaluating skeletal development of the large breed puppy. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Volume II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington: Orange Frazer Press, 1998; 13-28.
12. Rumph PF. Kinetic gait analysis in developing Great Dane dogs. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Volume II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington: Orange Frazer Press, 1998; 71-79.

Allan J. Lepine, PhD

Dr. Lepine received his Bachelor of Science in Animal Science from Cornell University in 1980, his Master of Science in Non-Ruminant Nutrition from Virginia Polytechnic Institute and State University in 1982, and his Doctor of Philosophy in Non-Ruminant Nutrition from Cornell University in 1987. The title of his PhD thesis was Metabolic and Endocrine Factors Affecting Glucose Homeostasis in the Fasting Neonatal Pig. Dr. Lepine joined The Ohio State University in 1987 as Assistant Professor in the Department of Animal Science. His teaching and research emphasis was in non-ruminant nutrition. In 1993 he accepted a position in the Research and Development Division of The Iams Company where he is currently Principal Research Nutritionist. Dr. Lepine's current research interests include dental nutrition, puppy and kitten nutrition, skeletal health, and the effects of nutrition on reproduction in companion animals.

Nutrition and the Immune System of Sporting Dogs

Stefan P. Massimino, MS
Michael G. Hayek, PhD
Michael A. Ceddia, PhD

INTRODUCTION

Altering the immune system through diet is an ever-growing area in pet food nutrition. Much work in this area has now been conducted, and this research has shown justification for a 'cradle-to-grave' mentality. By this, we mean that nutrition has been shown to play a beneficial role with the immune system in nearly every lifestage of the dog, from birth to death. Sporting dogs can specifically benefit from a stronger immune system. Fewer days missed due to illness, and an overall healthier dog are just two benefits for an adult dog, but there are benefits for both puppy and senior dogs as well. A puppy's immune system is immature and still developing, while senior dogs experience an age-associated decline in their functional immune system. Keeping sporting dogs productive and active into their golden years, or just happy and healthy as retired family pets, is another way that nutrition's effect on the immune system can help these dogs.

OVERVIEW OF THE IMMUNE SYSTEM

The immune system is an intricate network of specialized and interacting organs, tissues, cells, and chemicals. All dogs have various mechanisms to protect against invading disease agents (pathogens), ranging from non-specific barriers to specific defenses.

Immunity can be classified as either innate or acquired ***(Figure 1).*** Puppies are born with innate immunity, which consists of non-specific barriers, and cellular and chemical defense mechanisms. Non-specific physical barriers, such as skin and mucous membranes, protect against the initial entry of pathogens such as bacteria, viruses, and parasites. However, once those barriers are overcome, a functional immune system is required to mount a specific response to clear the infection and protect the dog.

Cellular and chemical defenses rely heavily on detection of the difference between invading microorganisms (called pathogens) and what is considered "self" or part of the individual's body. When these pathogens are detected, enzymes that digest bacterial cell walls are activated and cells that recognize these invading microorganisms and destroy them are deployed. This response is specific to the invading organism and does not require priming (no lag time), but is slow and usually not sufficient to clear the pathogen once it has become established. Rather, it serves to contain the infection until the next level of defense, known as acquired immunity, develops.

Acquired immunity is a much more complex system that can rapidly develop a specific response against invading pathogens. It can be divided into either cell-mediated or humoral immunity. Cell-mediated immunity includes the interaction of macrophages, B cells and T cells. These cells work together to generate an immune response by recognizing pathogens. Through cell to cell interactions and release of soluble immune mediators, production of additional T and B cells occurs. These cells are then responsible for sustaining the immune response, destroying the invading pathogen and infected cells, and terminating the immune response once the infection has been cleared. Some cells, known as memory cells, survive so that in the event of another attack by the same pathogen, the immune system is able to respond much more rapidly and vigorously.

Humoral immunity is also commonly referred to as the antibody-mediated immune response. When an invading pathogen has been recognized, pathogen-specific B cells proliferate

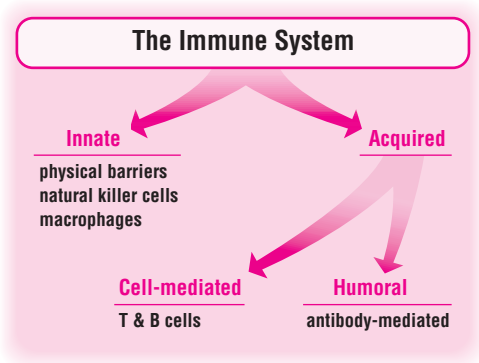

Figure 1. *Classifications of immunity.*

and are transformed into antibody-secreting cells. Antibodies are blood-borne immune proteins that are able to bind specifically with infected cells, as well as free microorganisms, which leads to their destruction. As with T cells, memory B cells remain after the infection to produce specific antibodies if the same pathogen is detected.

NUTRITION AND IMMUNE FUNCTION

Interactions between nutrition and immunity have been well-documented.[1] Diets deficient in protein, energy, minerals, vitamins, and essential fatty acids have long been known to impair immunity. More recently, supplementation with nutrients above and beyond minimum required levels has been reported to be successful in improving health and immune function in a wide range of species, including dogs. Specific nutrients that have attracted special interest for these purposes are antioxidants and fatty acids.

Antioxidants are thought to benefit immune function by their effects on free radicals. Free radicals are chemically reactive compounds that are produced daily in the body as a result of aerobic (oxygen-requiring) metabolism and normal immune system functioning. Therefore, free radical production is not only normal, but required as a consequence of having to breathe oxygen. However, if free radical accumulation is not controlled, it can damage healthy cells. The membranes that surround the various cells of the body are primary targets for free radical damage. Immune cells are especially susceptible to this free radical damage because their cell membranes contain high levels of polyunsaturated fatty acids, which are more easily damaged. The body has several systems in place to combat these free radicals, including antioxidant enzyme systems and various endogenous factors. Another alternative to these internal antioxidants are the various diet-derived antioxidants including vitamin E, beta-carotene, and lutein.

Vitamin E. Vitamin E is a term used to encompass a group of potent, chemically similar antioxidants. One form of vitamin E, alpha-tocopherol, is most abundant in the body, has the highest biological activity, and reverses vitamin E-deficiency symptoms. In cells, vitamin E contributes to cell membrane stability, regulates cell membrane fluidity, and protects cellular components from oxidative damage.[2] Immune cells possess a higher vitamin E level than other cells, and as previously mentioned, these cells coincidentally contain higher levels of polyunsaturated fatty acids making them more susceptible to oxidative damage. This might be one way in which immune cells try naturally to protect themselves from damage from free radicals.

Supplementation with vitamin E has been reported to increase lymphocyte proliferation and antibody production in several species.[3] Interleukin-2 production (a pro-inflammatory soluble immune mediator) and the delayed-type hypersensitivity response (an excellent determination of the cellular immune response; DTH) have also been reported to be elevated with vitamin E supplementation in older rodents and senior humans. Lastly, prostaglandin (PG) E_2 production (an immune-suppressing compound) was significantly decreased in rodents after vitamin E supplementation.

Beta-Carotene. Beta-carotene belongs to a family of antioxidants called carotenoids. Carotenoids are naturally occurring plant pigments that have been suggested to play important roles in modulating immunity and health of animals. Studies have shown that beta-carotene supplementation is able to affect both specific as well as nonspecific cellular defenses.[4,5]

Iams-sponsored studies have revealed that beta-carotene is effectively absorbed in dogs and can affect the canine immune system.[6-8] Studies in dogs have shown that beta-carotene supplementation results in increased antibody levels, an increased DTH response, modified immune cell numbers, and increased T and B cell proliferation responses. Feeding beta-

carotene has also been shown to improve various measures of immune function in senior, as well as young adult dogs.[9]

Lutein. Lutein is another naturally occurring carotenoid antioxidant found abundantly in plants and microorganisms. Unlike beta-carotene, lutein cannot function as a precusor for vitamin A synthesis (it cannot be used to make vitamin A in the body). However, like beta-carotene, lutein functions as an antioxidant protecting cell membranes from oxidative damage.

In dogs, lutein can be absorbed from the diet and taken up by lymphocytes.[10] Lutein supplementation in dogs has resulted in increased cell-mediated immune responses, such as the delayed-type hypersensitivity and lymphocyte proliferation after only 6 weeks. In addition, humoral immunity as measured by elevated antibody levels, was also increased in dogs with lutein supplementation.[11]

Taken together the above studies show that the antioxidant nutrients vitamin E, beta-carotene, and lutein have a positive influence on the immune system. Also noted in these studies is that these nutrients interact with different parts of the immune system. Therefore, incorporating a combination of these nutrients will have a stronger effect on the overall immune system than one nutrient alone.

Dietary Fat. Dietary fat has also been reported to modulate immune function. Historically it was thought that high-fat diets were responsible for suppressing the immune response.[12] However, work conducted within the last 10 to 15 years has shown that the type of fat in the diet plays an even larger role in modulating immunity. Omega-3 fatty acids exert their influence on the immune response by their ability to be incorporated into the cell membrane and act as substrates for eicosanoid metabolism. This results in the production of eicosanoids with lower inflammatory potential than those eicosanoids produced by the omega-6 fatty acid series.[13] Indeed, the 2-series prostaglandins, 2-series thromboxanes, and 4-series leukotrienes that are generated from the omega-6 fatty acid arachidonic acid, have been characterized as proinflammatory, proaggregatory, and thrombotic. This is in contrast to the 3-series prostaglandins, 3-series thromboxanes, and 5-series leukotrienes that are generated from the omega-3 fatty acid eicosapentanoic acid, which has been characterized as anti-inflammatory, anti-thrombotic, and vasodilatory. The ultimate goal of nutritional immunology is to regulate all these modifiable components of the immune system through nutrition, to bring about the desired response.

IMMUNITY IN THE PUPPY

When puppies are born, they emerge from a sterile environment (the uterus) to become exposed to a host of microorganisms, all of which are potentially pathogenic. Unfortunately, the immune system is not fully functional and developed for some time after birth. As a result, newborn puppies are especially vulnerable to infection in the first few weeks of life and require immune assistance in order to survive. This assistance is provided by the bitch, by transfer of immune cells and components through the colostrum and milk which immediately confers some level of immune protection for the newborn. This transfer of immunity from dam to newborn is very important for the newborn's survival.

The immune system then requires time to develop to its fully functional capacity ***(Figure 2)***. Both the distribution of immune cell types and their responses have been reported to change as puppies and kittens grow and develop. T cell populations are significantly smaller and their proliferation response to stimulation is less in puppies, compared with that in adult dogs. Only by 16 weeks of age, puppies have been reported to possess lymphocyte populations similar to that of healthy adult dogs.

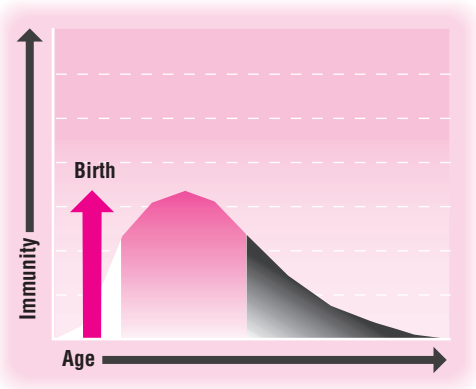

Figure 2. *Maturation and decline curve of the immune system in puppies.*

Unfortunately, puppy losses do occur during growth and development and mainly during specific times, including *in utero*, at birth, immediately after birth, and immediately after weaning. Losses during this postweaning period are typically as a result of disease brought on by a compromised immune system. Therefore, a stronger immune system as early as possible can help puppies grow and develop into healthy adult dogs.

A recent Iams-sponsored study[14] showed that puppies weaned (6 weeks of age) on a diet supplemented with the antioxidants vitamin E, beta-carotene, and lutein had higher levels of T cell activation ***(Figure 3)*** at 14 and 22 weeks of age when compared to their age-matched controls (puppies weaned on a diet containing standard vitamin E levels and no added lutein or beta-carotene). This effect was also seen for B cell activation ***(Figure 4)***. Puppies fed the antioxidant-supplemented diet also were seen to produce higher antibody levels to specific vaccines such as distemper, parvovirus, and parainfluenza ***(Figure 5)***.

To summarize, puppies can benefit from a boost in immune function since they possess a lower level of immune response when compared with adult dogs. During this vulnerable period, puppies are at a higher risk for developing disease. Previous research in adult dogs, as well as other species, shows that nutritional supplementation can influence immune function. This study showed that in puppies, dietary supplementation with antioxidants can improve both cell-mediated (T and B cell response) and humoral immune function (antibody production) which enhances the responses necessary to protect puppies against infectious disease.

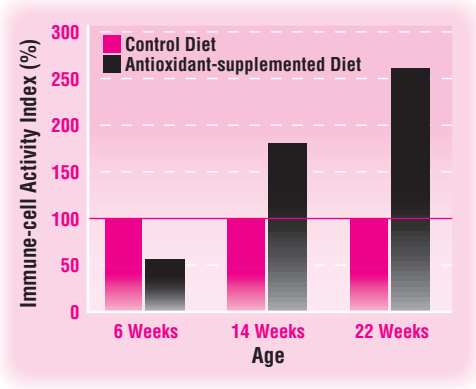

Figure 3. *T cell activity is increased in puppies fed diet with a specific antioxidant package.*

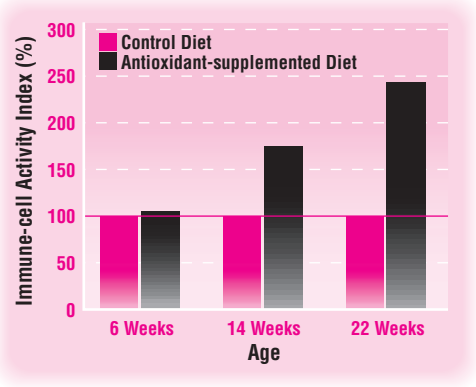

Figure 4. *B cell activity is increased in puppies fed diet with a specific antioxidant package.*

EXERCISE AND IMMUNITY

Once puppies have successfully grown into young adult dogs, and are ready to assume the role of a sporting dog, another factor which may potentially suppress their immune system comes into play: strenuous exercise. Sporting dogs generally will have a higher level of exercise incorporated into their daily routine when compared with non-sporting dogs. The interaction between exercise and immunology has only recently been known to exist, providing the basis for added protection for these sporting dogs. Although exercise in the long term is beneficial (lower percent body fat, higher percent lean body mass, improved cardiovascular system), acute levels of exercise produce short,

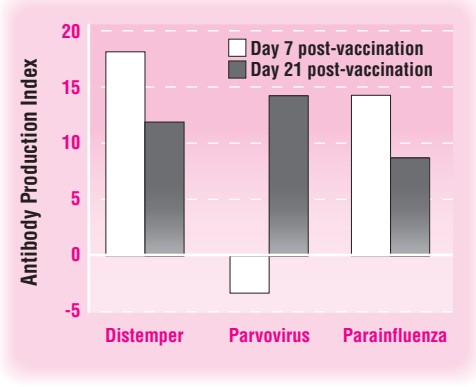

Figure 5. *Antibody production improves when puppies are fed a diet with a specific antioxidant package.*

but intense bursts of oxidative products such as free radicals. Increased levels of free radicals have been theorized to suppress various parameters of immune function. Indeed, many studies in the field of exercise immunology have reported fluctuations with immune cell numbers and function.

Natural killer cells are part of the innate immune system, and as such act as first barrier of defense against pathogens that breach the body's physical barriers. These cells are involved in the early response to viral infection and tumor growth. Natural killer cell cytotoxic activity increases acutely and proportionately with exercise intensity, and then returns to resting levels soon after brief to moderate exercise.[15,16] However, it continues to decline and remains below resting levels for up to 6 hours following intense and prolonged exercise.[17]

Neutrophils, which are also known as polymorphonuclear leukocytes, represent 50 to 60% of the total circulating leukocytes and also constitute part of the first line of defense against infectious agents. Once an inflammatory response is initiated, neutrophils are the first cells to be recruited to sites of infection or injury. Their targets include bacteria, fungi, protozoa, viruses, virally infected cells, and tumor cells. Studies have suggested that although acute exercise stimulates neutrophil function, prolonged periods of intense exercise are associated with downregulation of neutrophil function.[18]

Macrophages are a first line of defense against pathogens and malignancies by nature of their phagocytic, cytotoxic, and intercellular killing capacities. Ceddia and Woods demonstrated that exhaustive exercise suppressed macrophage function for up to 24 hr post-exercise.[19] This suppression in macrophage function was due to the inability of macrophages to degrade pathogens.[20]

Lymphocytes are also influenced by exercise. Lymphocyte stimulation has been reported to be particularly sensitive to exercise-induced changes. Brief, moderate exercise has little effect (it may actually slightly stimulate lymphocyte activation), but intense or prolonged exercise suppresses the proliferative response for up to 3 hours.[17]

The effect of intensive exercise on oxidative stress was examined in sled dogs. Several studies have examined the levels of oxidative stress markers released in the blood of sled dogs during a three day exercise bout (15–20 mile race per day for three days).[21-23] During this exercise period the authors noted increases in serum uric acid, isoprostane levels,[22] serum 7, 8-dihydro-8-oxo-2'deoxyguanosine and an increase in the lag time of in vitro oxidation of lipoprotein particles.[23] These results indicate an increase in free radical production due to the exercise regime.

Due to the increase in oxidative stress noted in the sled dog, it was of interest to determine if there is an effect on the immune system similar to that reported in other species.[7] In this study, 62 trained sled dogs were randomized to either a sedentary (n=22) or exercised group (n=21) or an exercised group receiving supplemental antioxidants (n=19). All dogs were fed a commercially available diet containing 35% protein, 30.8% fat, 23.1% carbohydrates, and an omega-6 to omega-3 fatty acid ratio of 5.9:1. Antioxidant supplementation consisted of 1 biscuit per day containing 21.6 mg beta-carotene and 18.4 mg lutein as well as 400 IU of alpha-tocopherol in the form of a softgel capsule.

Similar to observations in other species, several immune indices were altered due to the 3-day exercise session. The proportion of blood neutrophils were increased while the proportion of lymphocytes, eosinophils, and monocytes were decreased. Also a decrease in lymphocyte activity and alterations in the proportions of T cells and B cells were noted. Lastly, exercise resulted in an increase in the blood levels of acute phase proteins indicating that the exercise resulted in a generalized inflammatory response. Supplementation with antioxidants resulted in a normalization of the acute phase proteins as well as the proportions of certain T cells and B cells. These data demonstrate that supplementation with antioxidants result in alleviating some of the effects of exercise on the immune response.

AGING AND IMMUNITY

The dysregulation in immune function is a well-documented consequence of aging. This can lead to an increased incidence of morbidity (illness) and mortality (death). Cell-mediated immunity is clearly the component of the immune system most adversely affected with advancing age, primarily T cells. Age-related T cell immunity dysfunction has been implicated

as the cause of many chronic degenerative diseases in elderly humans, including arthritis, cancer, autoimmune diseases, and increased susceptibility to infectious diseases.

There are many theories that have been put forth to try and explain the mechanism(s) responsible for this decline, but no one theory can fully account for all the changes observed. The free radical theory of aging is particularly interesting. This theory is based on the premise that a single common process, modifiable by genetics and environmental factors, is responsible for the aging and death of all living things. Proposed by Harmon in 1956,[24] this theory suggests that aging is caused by free radical reactions and accumulation of reactive oxygen by-products.

As explained previously in this chapter, free radical production and accumulation can have several damaging effects on various cells, including those of the immune system. Therefore, much research with aging animals has been done looking at dietary antioxidants as a means of reducing free radical reactions and accumulation.

Senior dogs have been reported to show a decreased immune system response compared to younger dogs ***(Figure 6)***. Older dogs also differ in the make up of their immune system compared to younger dogs. Based on these observations, the aging process results in a dysregulation of the immune response in dogs too, as is similar with other species. Studies recently conducted by Iams have reported benefits from feeding senior dogs a diet supplemented with beta-carotene ***(Figure 6)***.

CONCLUSION

In conclusion, there is ample evidence to warrant nutritional support of the immune system through all walks of life for the sporting dog. There are not only issues with immune function through growth and development in the puppy and through decline in the senior dog, there are also issues that arise during certain conditions such as exercise. Studies have reported that nutrition, especially antioxidant supplementation, can help in all these scenarios. However, it is important to realize some of the dynamics behind antioxidant supplementation.

Studies have shown a dose-response with antioxidants like vitamin E and beta-carotene. At very high and very low levels, these antioxidants lose their effectiveness. There appears to be an optimal level for these compounds as far as immune function is concerned. Eukanuba™ dog foods are formulated with important antioxidants, such as vitamin E.

In summary, antioxidants such as vitamin E, beta-carotene, and lutein can improve several markers of immune function, thereby lowering the risk for infectious disease and ultimately helping the sporting dog to remain productive and stay healthy from puppyhood into senior years.

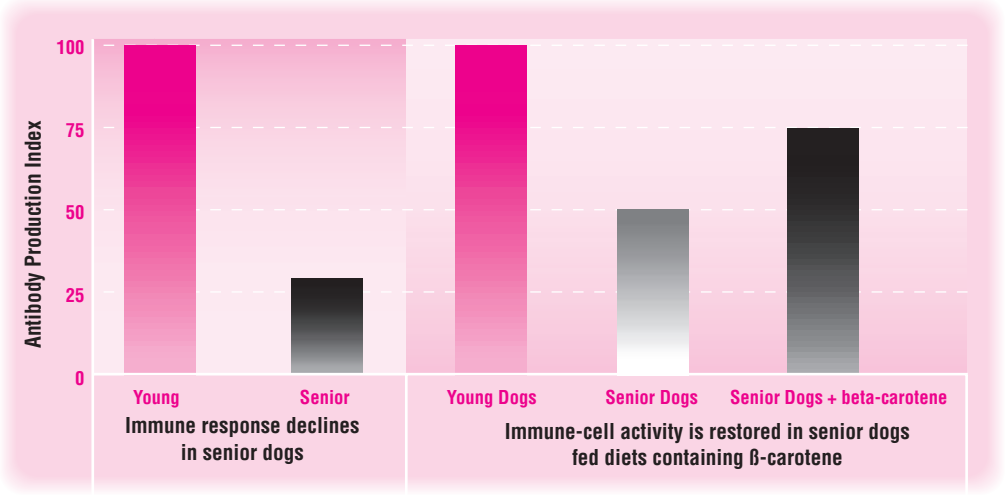

Figure 6. *Immune response in senior dogs and response to diet containing ß-carotene.*

REFERENCES

1. Gershwin ME, German BJ, Keen CL, eds. *Nutrition and Immunology; Principles and Practice*. Totowa, NJ: Humana Press, 2000.
2. Coquette A, Vray B, Vanderpas J. Role of vitamin E in the protection of the resident macrophage membrane against oxidative damage. *Arch Int Physiol Biochim* 1986; 94:S29-S34.
3. Meydani SN, Hayek, MG. Vitamin E and the immune response. In: Chandra RK, ed. *Proceedings of the International Congress on Nutrition and Immunity*. St. John's, Newfoundland, Canada: ARTS Biomedical Publishers and Distributors, 1992; 105-128.
4. Chew BP. Vitamin A and ß-carotene on host defense. Symposium: Immune function: Relationship of nutrition and disease control. *J Dairy Sci* 1987; 70:2732-2743.
5. Chew BP. Role of carotenoids in immune response. Symposium on "Antioxidants, Immune Response and Animal Function." *J Dairy Sci* 1993;76:2804-2811.
6. Chew BP, Park JS, Wong TS, Weng B, Kim HW, Byrne KM, Hayek MG, Reinhart GA. Importance of beta-carotene nutrition in the dog and cat: Uptake and immunity. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Vol II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 1998; 513-533.
7. Chew BP, Park JS, Kim HW, Wong TS, Cerveny C, Park HJ, Baskin CR, Hinchcliff KW, Swenson RA, Reinhart GA, Burr JR, Hayek, MG. Effects of heavy exercise and the role of dietary antioxidants in immune response in the Alaska sled dog. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Vol II: 2000 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 2000; 531-539.
8. Chew BP, Park JS, Weng BC, Wong TS, Hayek MG, Reinhart GA. Dietary ß-carotene is taken up by blood plasma leukocytes in dogs. *J Nutr* 2000; 130:1788-1791.
9. Kearns RJ, Loos KM, Chew BP, Massimino S, Burr JR, Hayek MG. The effect of age and dietary ß-carotene on immunological parameters in the dog. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition. Vol III. 2000 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 2000; 389-401.
10. Chew BP, Wong TS, Park JS, Weng B, Cha N, Kim HW, Byrne KM, Hayek MG, Reinhart GA. The role of dietary lutein in the dog and cat. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Vol II: 1998 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 1998; 547-554.
11. Kim HW, Chew BP, Wong TS, Park SJ, Weng BB, Byrne KM, Hayek MG, Reinhart GA. Dietary lutein stimulates immune response in the canine. *Vet Immunol Immunopathol* 2000; 74:315-327.
12. Vitale JJ, Broitman SA. Lipids and immune function. *Cancer Res* 1981; 41:3706-3710.
13. Reinhart GA. Review of dietary omega-3 fatty acids and dietary influences on tissue concentration. In: Carey DP, Norton SA, Bolser SM, eds. *Recent Advances in Canine and Feline Nutrition: Proceedings from the 1996 Iams Nutrition Symposium*. Wilmington, OH: Orange Frazer Press, 1996; 235-242.
14. Massimino SP, Daristotle L, Ceddia MA, Hayek, MG. The influence of diet on the puppy's developing immune system, in *Proceedings*. Canine Reproduction and Neonatal Health. Tufts Animal Expo 2001, 15-19.
15. Nielsen HB, Secher NH, Christensen NJ, Pedersen BK. Lymphocytes and NK cell activity during repeated bouts of maximal exercise. *Am J Physiol* 1996; 271:1 (Pt 2) R222-7.
16. Nieman DC, Miller AR, Henson DA, Warren BJ, Gusewitch G, Johnson RL, Davis JM, Butterworth DE, Nehlsen-Cannarella SL. Effects of high- vs moderate-intensity exercise on natural killer cell activity. *Med Sci Sports Exerc* 1993; 25:1126-1134.
17. Nieman DC, Simandle S, Henson DA, Warren BJ, Suttles J, Davis JM, Buckley KS, Ahle JC, Butterworth DE, Fagoaga OR. Lymphocyte proliferative response to 2.5 hours of running. *Int J Sports Med* 1995; 16:404-409.
18. Pyne DB, Baker MS, Fricker PA, McDonald WA, Telford RD, Weidemann MJ. Effects of an intensive 12-wk training program by elite swimmers on neutrophil oxidative activity. *Med Sci Sports Exerc* 1995; 27:536-542.
19. Ceddia MA, Wood JA. Exercise suppresses macrophage antigen presentation. *J Appl Physiol* 1999; 87:2253-2258.
20. Ceddia MA, Voss EW, Woods JA. Intracellular mechanisms responsible for exercise-induced suppression of macrophage antigen presentation. *J Appl Physiol* 2000; 88:804-810.
21. Hinchcliff KW, Reinhart GA, DiSilvestro R, Reynolds A, Blostein-Fujii A, Swenson RA. Oxidant stress in sled dogs subjected to repetitive endurance exercise. *Am J Vet Res* 2000; 61:512-517.
22. Hinchcliff KW, Piercy RJ, Baskin CR, DiSilvestro RA, Reinhart GA, Hayek MG, Chew BP. Oxidant stress, oxidative damage and antioxidants: Review and studies in Alaskan sled dogs. In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Vol II: 2000 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 2000; 517-530.
23. Baskin CR, Hinchcliff KW, DiSilvestro RA, Reinhart GA, Hayek MG, Chew BP, Burr JR, Swenson RA. Effects of dietary supplementation on oxidative damage and resistance to oxidative damage during prolonged exercise in sled dogs. *Am J Vet Res* 2000; 61:886-891.
24. Harmon D. Aging: A theory based on free radical and radiation therapy. *J Gerontol* 1956; 11:298-300.

Stefan P. Massimino, MS

Stefan Massimino is an alumnus of the University of Alberta where he received his BS in Food Science and Nutrition in 1995 and his MS in Nutrition and Metabolism in 1997. His graduate program focused on the effects of fermentable fiber on both glucose homeostasis and immune function in the dog. Mr. Massimino accepted a position with The Iams Company in 1998 as a research associate, and is currently an Associate Research Scientist in the Research and Development Division. As a member of the strategic research team, Mr. Massimino provides assistance with research efforts in the areas of geriatric nutrition, longevity, and the interaction between nutrition and the immune response.

Feeding for Endurance and Performance of Sporting Dogs

Gregory A. Reinhart, PhD
Eric K. Altom, PhD

INTRODUCTION

Diet and good nutrition play a critical role in sporting dog performance. Incorporating new nutritional findings into a practical feeding program can improve the dog's athletic success and enhance overall well-being. A manageable feeding program will also reduce stress on the handler/owner by easing the labor-intense burden typical in common feeding regiments.

What Makes a Successful Feeding Program?

A balanced diet for sporting dogs should…

- be rich in nutrients required by the dog
- meet energy requirements when fed in acceptable amounts
- include optimum protein levels
- include optimum fat levels
- have a fat profile that minimizes inflammation
- promote an acute sense of smell
- allow for repletion (replacement) of muscle glycogen
- contain the amount and type of fiber that promotes a healthy gut
- be palatable and readily accepted during training and especially while under the stress of competition
- be easy to prepare

Information presented in this chapter will focus on the endurance-enhancing effects of fat, the role of fat in the inflammation process, and fat's involvement in a dog's ability to smell.

SOURCES OF ENERGY

Exercise has a profound impact on the amount of energy required to maintain body condition. Different types of exercise (aerobic versus anaerobic, speed versus power) utilize different metabolic pathways to support muscle contraction.[1] These energy requirements are ultimately provided by three primary dietary sources: fat, protein, and carbohydrates. Nutritional programs designed for canine athletes should provide ample energy to support muscle contraction during athletic bouts while allowing the dog to benefit from training over the course of a season. Both the immediate needs of the muscle as well as longer term concerns such as aerobic capacity, proneness to injury, blood volume, and palatability can be met with the proper nutritional strategy.

Fat

Fat provides the most concentrated form of energy of all nutrients, is a source of essential fatty acids, and allows the absorption of essential fat-soluble vitamins. Dietary fat contains 8.5 kcal of metabolizable energy (ME)/gram and is over 2-fold more calorically dense than either dietary protein or carbohydrate. As fat content in a diet increases, the energy density (number of calories provided by the food in a given weight or volume) of the diet also increases. Fat also contributes to the palatability and acceptable texture of commercially prepared dog foods. Common sources of fat include chicken fat, tallow, lard, corn oil, safflower oil, soybean oil, sunflower oil, fish oils, and full fat flax/flax oil. Fat has a direct role in athletic performance and fitness.

Protein

Protein contains 3.5 kcal ME/gram and is less energy dense than fat. Dietary protein can be supplied by animal sources, plant sources (grains), or a combination of the two. In general, high-quality animal source proteins provide superior digestibility, amino acid balances, and palatability. However, animal protein sources can range from excellent quality to poor quality. The

nutritional quality of dietary protein sources is determined by protein digestibility and amino acid availability, which can only be determined through feeding trials. Animal protein sources commonly included in commercially prepared dog foods include chicken, chicken by-product meal, chicken meal, beef, dried egg, fish meal, meat and bone meal, meat by-products, meat meal, lamb, and lamb meal. The term "meat" can represent any species of slaughtered mammal but typically represents the striated muscle of pork, beef, or sheep. "By-products" may include secondary carcass components that can vary greatly in their nutritional quality. Depending on the supplier and how the meals are processed, by-product meals can have exceptional nutritional quality or be low in nutritional quality due to higher amounts of indigestible ingredients. Fed in excess, high-quality animal proteins are an expensive source of carbon intermediates for energy production.

Common sources of grain proteins in dog foods include corn gluten meal, soy flour, soy grits, soybean meal, and wheat germ. Lower cost dog foods that are formulated predominantly with vegetable protein sources often use a combination of soy products and corn gluten meal to compensate for the low levels of the essential amino acid found in corn gluten (deficient in lysine and typtophan) or soy (deficient in methionine).

Exercise increases an athlete's protein requirement. A commonly held belief is that the increased protein needs of exercising dogs can be met solely by increasing nutrient intake and that specific dietary modifications are not required. A study with sled dogs compared the metabolic responses to training in dogs fed diets deriving 16, 24, 32, and 40% of their calories from high-quality animal protein. Fat levels were kept constant and the source of protein did not differ between diets. It was observed that dogs fed the highest protein level maintained a larger plasma volume and red blood cell mass during strenuous training.[2] It was also observed that all of the dogs consuming the low-protein diet had at least one injury during the racing season that resulted in it being removed from training for a minimum of one week. Only 2 out of 8 dogs fed the 24% of calories from protein diet had serious injuries while none of the dogs fed the higher protein level diets had injuries.[2] This research suggests that an adult athletic dog may have a ***minimum*** protein requirement of 24% of ME calories. This is substantially different from the 18% of ME calories for adult maintenance recommended by The Association of American Feed Control Officials.

Carbohydrates

Ingredients that contribute dietary carbohydrates in the sporting dog's diet include various forms of corn, rice, wheat, sorghum, barley, potato, and oats. These ingredients contribute complex carbohydrates in the form of starch that is highly available when properly cooked. Feeding uncooked grains will often result in loose stools and flatulence, an indication of poor nutrient availability. Other sources of carbohydrates include molasses and certain types of hydrolyzed starches. Dietary carbohydrates provide sporting dogs with a source of energy. A limited amount of carbohydrate can be stored in the body as glycogen with excess metabolized to body fat for energy storage. Carbohydrates provide 3.5 kcal ME/gram and are less nutrient dense than fat.

ENERGY REQUIREMENTS

Diets for the canine athlete need to have dietary sources of fat, protein, and carbohydrates in appropriate proportions to meet energy needs and optimize athletic performance. Achieving energy balance is very important in any dog—it is critically important from a competitive standpoint in sporting dogs. The ideal situation is for energy expenditure to equal energy intake and avoid large variations in body weight. Positive energy balance occurs when caloric intake exceeds energy expenditure and results in an increase in the quantity of fat stored by the body. Negative energy balance occurs when caloric intake is lower than energy expenditure, resulting in weight loss and a decrease in both fat and muscle mass. Either of these latter two situations will compromise athletic performance.

Both physical and environmental stresses result in increased energy needs in sporting dogs. Short bouts of intense physical activity may cause only a small increase in energy needs while long distance training and/or prolonged sporting events can substantially increase energy needs. Environmental conditions commonly associated with sporting dogs will also increase energy demands, with additional energy expen-

diture required to enhance cooling mechanisms in warm conditions or support normal body temperature in cold conditions. The total energy needs of a sporting dog consist of a maintenance energy requirement, a voluntary muscular activity requirement (exercise), and a thermoregulation energy requirement. The actual calories per day a dog needs will vary widely depending on the type of exercise, the individual dog's metabolism and the environment in which it is working.

For example, a conditioned Greyhound may require an additional 10–20% above maintenance energy requirements, while long distance sled dogs require up to 11,250 kcal ME per day (4–5 times increase in energy needs due to exercise).[3] The other extreme involves military working dogs in hot humid environments in which 50–100% more energy is required than similar dogs in less environmentally stressful conditions.[4] The best recommendation remains to feed each individual animal to a body condition that is appropriate for the sport and environmental conditions in which it is participating.

Dietary Fat

Dietary fat is a concentrated source of readily available energy, provides essential fatty acids, and enhances palatability. Dietary fat is in a classification of compounds known as lipids. The most common source of dietary fat are the simple lipids, which includes the triglycerides. Triglycerides are composed of three fatty acids linked to one molecule of glycerol. Dietary fats (triglycerides) in the diet can be differentiated according to the type of fatty acids that each triglyceride contains. Recent scientific findings from canine nutritional studies have revealed new concepts on how much and what types of fat (fatty acids) to feed to athletic dogs.

Fat and Endurance

It is generally accepted that energy is the nutrient of most concern for sporting dogs, yet the "optimal" method of supplying this energy in the diet has been controversial. It is well recognized in human athletic events that an important limiting factor in prolonged exercise is the amount of glycogen present in the working muscles and that onset of fatigue is highly correlated with muscle glycogen depletion.[5] However, unlike the human, the dog derives approximately 70–90% of the energy for muscle contraction from fat metabolism and only a small amount derived from carbohydrate metabolism.[6] These laboratory findings are consistent with research in sled dogs[7,8] and Beagles[9] in which the ability to use fatty acids through aerobic pathways for energy is more important for performance than the use of muscle glycogen through anaerobic pathways.

A controlled study was conducted in which Alaskan Huskies were fed either a high-fat (60% fat, 25% protein, 15% carbohydrate on an energy basis) or a high-carbohydrate (15% fat, 25% protein, 60% carbohydrate) diet for a one month acclimation period, followed by 6 months of exercise tests. At the beginning of the exercise tests, animals fed the high-fat diet had significantly higher levels of circulating free fatty acids (FFA) during aerobic exercise tests than dogs fed the high carbohydrate diet.[10]

One of the major determinants of the amount of fat used for muscle contraction is the concentration of FFA in the bloodstream. By increasing plasma FFA levels, the high-fat diet facilitated FFA utilization during exercise. This phenomenon has been further documented in Labrador Retrievers which have a 45% increase in maximal fat oxidation when fed a high-fat (65% of energy) compared to a low-fat (25% of energy) diet.[11] These same dogs also had nearly a 50% increase in VO_2 max ***(Figure 1)*** and a 40% increase in mitochondrial volume in biopsies of the *Triceps brachii* ***(Figure 2)*** when fed a high-fat diet.

VO_2 max is an indicator of fitness and mitochondria are the subcellular compartments that "burn" fat. It is proposed that feeding a high-fat diet stimulates growth of mitochondria and thereby increases maximal rates of fat oxidation (amount of fat "burned"), aerobic capacity, and endurance in Labrador Retrievers until they reach the high endurance levels of sled dogs. In essence, feeding a high-fat diet to a Labrador Retriever produces an animal that has an aerobic capacity and mitochondrial volume density indistinguishable from that of a sled dog. This strongly suggests that the legendary endurance of sled dogs may be due to diet and not to generations of selective breeding. These results further imply that diet may have a primary role in stamina and performance from a practical standpoint, since training is typically associated with only a 15–20% increase in VO_2 max and maximal fat oxidation.[18]

Type of Fat

The benefits of dietary fatty acid supplementation are receiving increased attention in the veterinary medical[12] and sports exercise physiology fields. The ability of dietary omega-3 fatty acids to reduce the concentrations of inflammatory compounds in canine skin, plasma, and neutrophils has been reported.[13] The reduction in the inflammatory response is due to the competitive inhibition of omega-3 fatty acids on the production of omega-6 fatty acid metabolites. Omega-3 fatty acids are found in high concentrations in marine oil (coldwater fish) and certain terrestrial plant oils (flax). Enriched sources of omega-6 fatty acids include terrestrial plant oils (corn, safflower, canola, soy) and animal fats ***(Table 1)***.

Because omega-6 and omega-3 fatty acids compete for the same enzyme systems, the ratio between these two types of fatty acids in the diet is very important. This ratio determines the relative proportions of the respective omega-6 (proinflammatory) and omega-3 (less inflammatory) metabolites that are produced. Research in the dog has demonstrated that a dietary omega-6:omega-3 fatty acid ratio between 5:1 and 10:1 reduces the production of inflammatory mediators in canine skin and blood.[13] Dietary omega-6:omega-3 fatty acid ratios between 5:1 and 10:1 also meet the essential omega-6 fatty acid requirement but do not alter blood clotting or wound healing.[14,15]

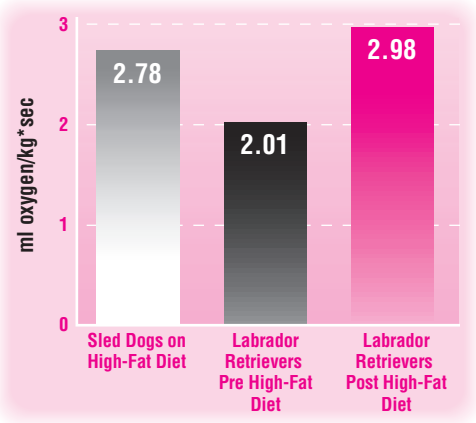

Figure 1. *Dietary fat increases VO_2 max in sporting dogs.*

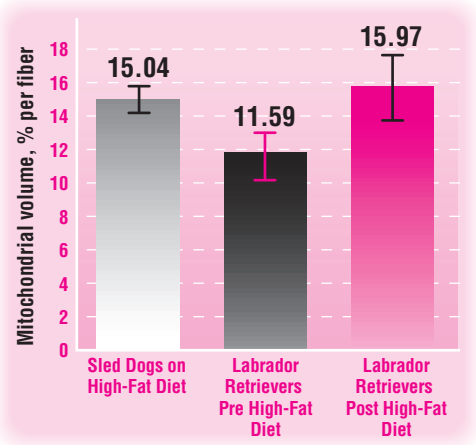

Figure 2. *Dietary fat increases mitochrondrial volume in sporting dogs.*

Fat and Smell

Many aspects of canine athletic performance are dependent on the ability of the dog to smell. Dietary fats will change the fatty acid composition of many cells in the body, including those cells that line the canine nose and are involved in olfaction (smell). A recent study evaluated the effect of dietary fatty acid composition on the nasal epithelium of canine athletes and the ability to affect olfactory function.[16] This work demonstrated that feeding saturated fatty acids to male Pointers decreased olfactory perception. It has been speculated that unsaturated fatty acids (ie, omega-3 fatty acids, omega-6 fatty acids) increase cell membrane fluidity which in turns

Table 1. *Sources of omega-6 and omega-3 fatty acids; n=omega*

DIETARY OMEGA-3 FATTY ACID SOURCES	
Coldwater fish oils	12–15% eicosapentaenoic acid (20:5n-3) 8–10% docosahexaenoic acid (22:6n-3)
Flax oil (linseed)	57% alpha-linolenic acid (18:3n-3)
Canola oil (rapeseed)	8% alpha-linolenic acid (18:3n-3)
Soybean oil	7% alpha-linolenic acid (18:3n-3)
DIETARY OMEGA-6 FATTY ACID SOURCES	
Corn oil	70% linoleic acid (18:3n-6)
Safflower oil	78% linoleic acid (18:3n-6)
Sunflower oil	69% linoleic acid (18:3n-6)
Cottonseed oil	54% linoleic acid (18:3n-6)
Soybean oil	54% linoleic acid (18:3n-6)
Chicken fat	16% linoleic acid (18:3n-6)
Pork fat (lard)	15% linoleic acid (18:3n-6)

increases the likelihood of a compound being detected by the dog. This information implies that a balanced omega-6:omega-3 fatty acid ratio in the diet may enhance olfactory acuity.

Fat may also play a key role in the ability to smell in another way. Dogs that are not in adequate physical condition breathe more through the mouth during periods of intense exercise as opposed to breathing through the nose. Intense exercise also increases the amount of air that must be exchanged and this forces more air through the lungs and out of the mouth (as opposed to the nose). It is probable that decreasing the amount of air flow through the nasal passages reduces the amount of odorants passing over the olfactory membranes. This would substantially decrease the smelling capacity of the dog during intense exercise. Conversely, a canine athlete in top physical condition would be able to reduce the amount of air breathed through the mouth and increase the air travelling through the nose.[16]

Work in the Labrador Retriever has clearly shown that high-fat diets increase aerobic capacity and endurance compared to low-fat diets.[2] Thus, a dog fed a high-fat diet with an appropriate level of omega-3 fatty acids is more likely to be in better physical condition, breathe more air through its nose, and more likely to pick up smells in the air travelling through the nasal passage. Taking all these factors into consideration, it is apparent how fat level and type can play a direct and indirect role in canine olfaction.

IMPORTANCE OF MUSCLE GLYCOGEN

Glycogen is the storehouse for carbohydrates in the body. The glycogen found in the muscles, including the heart muscle, supply "fuel" to the muscle cells. Muscle glycogen levels can decrease dramatically during endurance exercise in athletic dogs. The ability and desire for canine athletes to resume exercise after a rest period (whether hours or days) is often related to muscle glycogen levels. Therefore, a major goal when feeding endurance athletes is to increase muscle glycogen stores and/or delay muscle glycogen depletion during exercise. Even though dogs rely predominantly on fat burning for exercise, muscle glycogen depletion remains associated with fatigue and recovery.

The conventional approach of "glycogen loading" by feeding high-carbohydrate diets has not resulted in positive results in the canine. This performance failure in exercising dogs fed high-carbohydrate diets has been attributed to excessive lactate production during the rest-to-exercise transition[17] and a decrease in food energy density.[9] Recently, when sled dogs fed high-carbohydrate diets were compared to animals fed high-fat diets, both higher resting muscle glycogen levels and accelerated muscle glycogen utilization during exercise were observed.[8] The potential benefits of higher resting glycogen levels were offset by the rapid utilization of these carbohydrate stores during exercise. Conversely, dogs fed the high-fat diet were able to "spare" muscle glycogen levels and maintain adequate muscle glycogen throughout both anaerobic and aerobic exercise tests.

Glycogen sparing may be a more sound strategy for endurance than glycogen loading in sporting dogs. The challenge is to nutritionally increase muscle glycogen storage while feeding diets enriched in fat and protein. This novel approach was tested in a field research study with Alaskan sled dogs. Sled dogs typically consume diets low in carbohydrates (< 15% of ME kcal during racing events) and would not be expected to fully replete muscle glycogen levels due to diet and short rest periods between exercise bouts. The sled dogs participated in an exhaustive training run designed to significantly decrease muscle glycogen levels. Immediately after exercise they were provided either water or water baited with glucose polymers (partially hydrolyzed corn starch) to achieve a targeted total dose of 1.5 g carbohydrate/kg bodyweight. The sled dogs receiving the glucose polymer supplementation demonstrated significantly greater muscle glycogen repletion during the first four hours of recovery than non-supplemented dogs ***(Figure 3)***. Carbohydrate supplementation immediately after exercise also increased plasma glucose concentrations 100 minutes post-exercise.[2]

Thus, it appears that two nutritional strategies are beneficial for improving endurance and delaying fatigue: 1) feeding to enhance the ability of working muscles to preferentially use fatty acids for energy [and spare muscle glycogen] and 2) post-exercise supplementation of small amounts of carbohydrate to increase muscle glycogen stores. Strategic feeding of readily available carbohydrates immediately post-exer-

cise allows repletion of muscle glycogen without significantly "diluting" the diet with carbohydrate calories.

FAT SOLUBLE VITAMINS/ ANTIOXIDANTS

During aerobic exercise, oxidative stress and oxidative damage are elevated. Canine athletes may be especially prone to oxidative damage because their training and participation in events requires repetitive long-term endurance exercise and high energy expenditures. For example, Iditarod sled dogs with exertional rhabdomyolysis ("tying up") have been found to have low tissue vitamin E concentrations. Controlled research has demonstrated that sled dogs involved in repetitive endurance exercise bouts have increased lipid peroxidation and reduced serum antioxidant concentrations.

The canine athlete appears to benefit from selected antioxidant supplementation. The benefits are enhanced performance and reduction of oxidative damage. Sled dogs with higher pre-race vitamin E levels were 1.9 times more likely to finish a 1150 mile race.[18] The data did not, however, suggest a direct benefit of antioxidant status and the likelihood of developing exertional rhabdomyolysis.

It is recommended that exercising sporting dogs be supplemented with 200 IU of vitamin E per day over what they are currently receiving in a typical diet. This amount of supplementation will achieve the blood levels necessary for a performance benefit. This vitamin E should be in the form of alpha-tocopherol. Human vitamin E supplements in the form of alpha-tocopherol are commercially available in 200 IU capsules and these can be given to dogs. There are no known contraindications to recommending this level of additional vitamin E supplementation.

The source of the vitamin E used for supplementation is very important. There are many forms of vitamin E. The preferred type (most biologically active form) is alpha-tocopherol. It is recommended that alpha-tocopherol, alpha-tocopherol acetate, or alpha-tocopherol succinate be used. Avoid cheap vitamin E supplements that contain high levels of vitamin A. Providing this type of vitamin supplement to dogs on a long term basis could lead to an overdose of vitamin A and development of vitamin A toxicity.

Antioxidant (vitamin E) supplementation must be approached in a prudent manner and extremes avoided. Vitamin E is absorbed into the body by the same route as the other fat soluble vitamins (vitamins A, D, and K). Higher levels of vitamin E may compete with the other fat soluble vitamins for absorption and result in lower uptake of these necessary nutrients. High levels of vitamin E supplementation (1,000 IU per day) in Greyhounds have impaired performance.[19] Excessive vitamin E intake has resulted in bleeding disorders, presumably due to an induced vitamin K deficiency (too much vitamin E impaired vitamin K from being absorbed at the amounts required for normal blood clotting.)

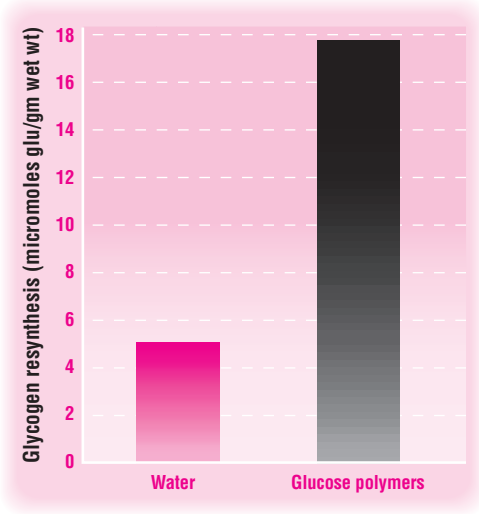

Figure 3. *Post-exercise carbohydrate supplementation increases muscle glycogen resynthesis.*

TRAINING AND DIET

Commercial diets formulated for athletic performance should be energy dense and highly palatable. Overfeeding this type of ration to a sporting dog not in heavy training will invariably lead to a loss of condition and even obesity. However, this does not imply that the recommended nutritional approach used for training and athletic competition should be altered in the off-season or during periods of lower work output. Transitioning a well conditioned sporting dog to a diet lower in fat and protein and/or lower quality ingredients is the metabolic

equivalent to "detraining" that animal. Higher dietary fat levels are needed to maintain aerobic capacity, endurance and resistance to fatigue. Changing to lower fat diets will decrease the stamina and endurance of canine athletes. When this decrease in metabolic capacity is coupled with decreased training, the sporting dog will experience a rapid decline in fitness.

Wide fluctuations in fitness are best avoided when possible; feeding a high-quality diet year round is an easy method of minimizing the decrease in fitness associated with the off-season. This does, however, create an increased emphasis for attention to detail when feeding the sporting dog and the importance of observing body condition. Remember, it is always best to feed athletic dogs based on body condition. It is more appropriate to make adjustments in the amount that is fed and not decrease the quality or energy density of the diet. Maintaining an animal on a fairly constant nutritional program is also less likely to induce gastrointestinal stress that is common during changeovers in feeding practices.

It takes approximately 6 weeks for the increase in VO_2 max, mitochondrial volume increases, and increases in maximal fat oxidation to occur after feeding high-fat diets to dogs. For this reason, a higher plane of nutrition should be implemented a minimum of 6 weeks prior to the beginning of training. Failure to metabolically adapt canine athletes prior to training will drastically reduce the animal's ability to benefit from training and perform at peak capacity.

PRACTICAL RECOMMENDATIONS

Based on numerous studies with canine athletes, the nutritional recommendations shown in ***Table 2*** will benefit their health and performance.

Strategic carbohydrate feeding should be utilized with this nutritional program and can increase muscle glycogen repletion (or restoration). A post-exercise intake of 1.5 gm glucose polymers/kg body weight is suggested for every training and/or competition bout. Polycose© (Ross Products, a division of Abbott Laboratories) partially hydrolyzed corn starch, or a similar carbohydrate is mixed with water (roughly a pint). This should be offered to the dogs within 30 minutes after the end of the exercise; to wait longer misses the benefit.

The recommendations forwarded by these recent research findings have applications to dogs that participate in:

- Shooting trials
- Retriever trials
- Herding dog trials
- Search and rescue missions
- Agility competitions
- Greyhound races
- Obedience trials
- Coonhound trials
- Bloodhound competitions
- Police dog work
- Beagle field trials
- Foxhound races
- Military operations
- *Schutzhund* trials
- Frisbee competitions
- German obedience competitions

Table 2. *Nutritional recommendations for feeding canine athletes and associated benefits*

NUTRIENT	RECOMMENDATION
Energy Density	4,000 kcal ME/kg or greater
Fat	50–65% of calories or greater
Protein	30–35% of calories or greater; animal based sources
Fatty Acid Profile	omega-6:omega-3 ratio between 5:1 and 10:1
Carbohydrate	10–15% of calories
Total Dietary Fiber	3–7% of dry matter; moderately fermentable

BENEFITS

- Increased aerobic capacity and endurance
- Increased utilization of fatty acids to provide energy for muscle contraction
- Decreased level of inflammatory reactions in the body
- Decreased injury rate
- Improved intestinal health including small firm stools
- Reduced feeding volumes

CONCLUSION

The performance of any sporting dog is only as good as genetics, training, and diet can support. Any one of the three can have sufficient influence to make or break an effort. Diet is critical and several factors have been shown

to improve performance and enhance well-being under physical stress. If nutrition is used properly, it provides a foundation for effective training and performance; if abused it will handicap the benefits derived from training and ultimately affect performance.

REFERENCES

1. Grandjean D, Paragon BM. Nutrition of racing and working dogs. Part I. Energy metabolism of dogs. *Compendium* 1992; 1412:1608-1615.
2. Reynolds AJ, Taylor CR, Hoppler H, Weibel E, Weyand P, Roberts R, Reinhart GA. The effect of diet on sled dog performance, oxidative capacity, skeletal muscle microstucture, and muscle glycogen metabolism. In: Carey DP, Norton SA, Bolser SM, eds. *Recent Advances in Canine and Feline Nutritional Research: Proceedings of the 1996 Iams International Nutrition Symposium*. Wilmington OH: Orange Frazer Press, 1996; 181-198.
3. Hinchcliff KW, Reinhart GA, Burr JR, Schreier CJ, Swenson RA. Metabolizable energy intake and sustained energy expenditure in Alaskan sled dogs during heavy exertion in the cold. *Am J Vet Res* 1997; 58:1457-1462.
4. McNamara JH. Nutrition for military working dogs under stress. *Vet Med Sm Anim Clin* 1972; 67:615-623.
5. Bergstom J, Hermansen L, Hultman E, Saltin B. Diet, muscle glycogen, and physical performance. *Acta Physiol Scand* 1967; 71:140-150.
6. Theriault DG, Beller GA, Smoake JA, et al. Intramuscular energy sources in dogs during physical work. *J Lipid Res* 1973; 14:54-61.
7. Hammel EP, Kronfeld DS, Ganjan VK, Dunlap HL. Metabolic responses to exhaustive exercise in racing sled dogs fed diets containing medium, low, or zero carbohydrate. *Am J Clin Nutr* 1976; 30:409-418.
8. Reynolds AJ, Fuhrer L, Dunlap HL, Finke M, Kallfelz FA. Effect of diet and training on muscle glycogen storage and utilization in sled dogs. *J Appl Physiol* 1995; 79:1601-1607.
9. Downey RL, Kronfeld DS, Banta CA. Diet of beagles affects stamina. *J Am Anim Hosp Assoc* 1980; 16:273-277.
10. Reynolds AJ, Fuhrer L, Dunlop HL, Finke MD, Kallfelz FA. Lipid metabolic responses to diet and training in sled dogs. *J Nutr* 1994; 124:2754S-2759S.
11. Reynolds A, Hoppeler H, Reinhart G, Roberts T, Simmerman D, Weyand P, Taylor C. Sled Dog Endurance: A Result of High Fat Diet or Selective Breeding? *FASEB J* 1995; 9:A996.
12. Logas D, Beale KM, Bauer JE. Potential clinical benefits of dietary supplementation with marine-life oil. *JAVMA* 1991; 199:1631-1636 .
13. Vaughn DM, Reinhart GA, Swaim SF, Lauten SD, Garner CA, Boudreaux ML, Spano JS, Hoffman CE, Conner B. Evaluation of effects of dietary n-6 to n-3 fatty acid ratios on Leukotriene B synthesis in dog skin and neutrophils. *Vet Derm* 1995; 5:163-173.
14. Boudreaux MK, Reinhart GA, Vaughn DM, Mooney M. The effects of varying dietary n-6:n-3 fatty acid ratios on platelet reactivity, coagulation screening assays, and antithrombin III activity in dogs. *J Am Anim Hosp Assoc* 1997; 33:235-242.
15. Mooney MA, Vaughn DM, Reinhart GA, Powers RD, Wright JC, Hoffman CE, Swaim SF, Baker HJ. Evaluation of the effects of omega-3 fatty acid-containing diets on the inflammatory stage of wound healing in dogs. *Amer J Vet Res* 1998; 59: 859-863.
16. Altom EK. *Effect of dietary fat and physical conditioning on the metabolic and physiological responses of the canine athlete* [dissertation]. Auburn, AL: Auburn University; 1999.
17. Kronfeld DS. Diet and performance of racing sledge dogs. *J Am Vet Med Assoc* 1973; 162:470-473.
18. Piercy RJ, Hinchcliff KW, Morley PS, Disilvestro RA, Reinhart GA, Nelson SL, Schmidt KE, Morrie Craig A. Association between vitamin E and enhanced athletic performance in sled dogs. *Med Sci Sports Exerc* 2001; 33:826-33.
19. Hill R. Oxidative stress in racing Greyhounds, in *Proceedings*. 18th Annual International Canine Sports Medicine Symposium, 2002; 15-21

Gregory A. Reinhart, PhD

Dr. Reinhart is an alumnus of The Ohio State University where he received his BS in Animal Science in 1983, his MS in Non-Ruminant Nutrition in 1985, and his PhD in Nutritional Biochemistry in 1989. Dr. Reinhart joined Ross Laboratories Medical Nutrition Department in 1989 as a Clinical Research Associate. In 1990 he accepted a position with The Iams Company in the Research and Development Division where he is currently Vice President of Strategic Research and Communications. His research interests include fatty acid metabolism, fiber nutrition, mineral metabolism and geriatric nutrition of dogs and cats. Dr. Reinhart is also actively involved in investigating the nutritional needs and exercise-induced physiological changes in Alaskan sled dogs. He was awarded the International Sled Dog Veterinary Medical Association Tom Cooley Memorial Research Award for these efforts. Dr. Reinhart has published over 130 scientific papers and abstracts in peer reviewed journals and is co-editor of *Recent Advances In Canine and Feline Nutrition* volumes II and III. He has also presented at international symposia and conferences in more than 25 countries.

Dietary Protein and the Kidney in the Field Trial Dog

Daniel P. Carey, DVM

INTRODUCTION

You have probably heard stories about it. You may even know of someone who has "seen" it happen in one of their sporting dogs. It may have occurred in one of yours. Renal failure in dogs is a sneaky disease that affects about 15% of dogs in their later years. The form most commonly seen is "chronic" renal failure. That means the kidneys have been failing to perform their function for months. The interesting thing about chronic renal failure is that the cause is seldom known. Unlike many diseases that have a cause closely timed with the obvious signs of the disease, chronic renal failure is the kidney's response to an insult that may have occurred months or even years earlier.

Chronic renal failure (CRF) can mimic some other diseases but generally is noticed by owners when their dog drinks more water than expected and urinates more volume than is normal. This is called polydipsia (excessive drinking) and polyuria (excessive urination). Other diseases that show these signs include sugar diabetes (diabetes mellitus), liver failure, pyometra (uterine infection in bitches), several hormonal diseases, and psychology. The psychological part is called psychogenic drinking and simply means the dog is drinking and, subsequently urinating, too much just because he wants to—no disease present, just a water-holic. The other conditions are serious or potentially serious, so it is important that any dog with polydipsia and/or polyuria be seen by a veterinarian for diagnosis. Most of these diseases can be treated.

If a dog does have renal failure, the kidney is no longer doing its job. The waste products of metabolism that are usually filtered out and removed by the kidney begin to build up in the blood. As the waste products build up, the dog will start to feel bad. When this occurs, the kidney is probably already about 75% damaged. When CRF occurs, the damage is irreversible. In fact, it has always been felt that CRF is progressive; it will continue to get worse. Although no one yet knows how to stop the progression of CRF, there are ways to slow the progression. A special diet is involved. More on that in a moment.

CRF "Myths"

There is a long-standing myth that diet can prevent CRF. That is not the case. Many studies of dogs have been conducted and none have found that diet causes the kidneys to fail. However, once a dog has CRF, diet is important for slowing the progression of the disease and making the patient feel better. But feeding a renal failure diet to "prevent" CRF does not work. There is the myth, though, that protein in the diet is somehow involved. It is not true, as we shall see.

Few topics in veterinary clinical nutrition have been as widely discussed, uniformly accepted, and frequently applied as dietary protein levels and the canine kidney. For years, veterinary students in North America have been taught that chronic renal failure is progressive and that the some of the signs of the disease are due to metabolic waste from protein. The link between protein and progression was not proven but was suspected and incorrectly promoted by some. At the same time, some veterinary medical foods, claiming to be appropriate for the disease, seemingly validated the connection between the progression of the renal damage and dietary protein. The resulting confusion has led a large number of practicing North American veterinarians to believe that dietary protein is actually involved in the etiology of chronic renal failure.

This misunderstanding has changed as new, scientifically sound studies have been conducted and published. Current reports are building upon the groundwork laid over the past 20 years of investigations and rely not only upon developments in veterinary medicine but also nutritional science and pet food processing.

CHRONIC RENAL FAILURE AND PROGRESSION

Chronic renal failure is characterized as irreversible and progressive with clinical signs developing as the regulatory and excretory functions of the kidney decrease. Numerous causes have been identified including trauma, infection, immune disease, cancer, circulation problems, genetic abnormalities, and toxins.[1] In most cases, the initiating factor(s) are no longer present when clinical signs are first noticed. This is the result of significant compensation by the remaining kidney tissue after the inciting cause is removed. With time, however, most cases progress. The reason for the progression is not yet clear, and the absence of a consistent rate of progression makes it difficult to study. Several hypotheses have been suggested with the current emphasis placed on increased blood pressure inside the kidney and too much work being handled by the remaining kidney tissue.

Rat studies have shown that dietary changes which limit the extra "work" by the failing kidney and limit the blood pressure changes within the kidney also slow the progression of the disease.[2,3] Because the adverse affects may be linked to the adaptive changes necessary for compensation, it is possible that improper dietary manipulations could actually slow the kidney's adaptation. Although much attention has been given to protein, other factors such as sodium, lipid (fat) and energy intake have also been studied.[4] Indeed, the effects attributed to protein intake in some early studies appears to be due to reduced calorie intake rather than protein!

High-protein intakes increase the blood flow through the kidney's microscopic filters in all species studied, including the dog. This effect is noted in both healthy animals and those with damaged kidneys.

Information gained from the rat kidney failure studies has helped advance our knowledge on the subject. However, there are key differences between rats and dogs that make direct extrapolation of rat results invalid. For instance, many of the rat models used have spontaneous renal disease associated with aging. The rat also continues to grow throughout its life while the dog reaches a mature size early and then maintains that size. This might explain part of the longevity effects of caloric restriction in rats.

DOG STUDIES

The relationship between protein intake and the progression of kidney failure seen in rats has not been found in the dog. Contrary to the rat findings, increased protein levels ***have not*** been shown to be related to the progression of renal disease in dogs with experimental or natural renal disease.[5,6] Dogs do experience overloaded function of remaining kidney tissue and increased kidney blood pressure, but moderate protein restriction (16% dietary protein) does not prevent its development.[7] Further, a direct relationship between protein intake and kidney filtering has been shown in the dog—that is a good function—protein is beneficial.

In one study, diets containing either 19, 27 or 56% protein were fed to dogs with significantly reduced kidney function for a period of four years.[5] In contrast to the rat studies, increased protein intake was not associated with any clinical signs of kidney disease. Although the diets used in this study had more variables than just protein level and the dogs did not have kidney disease to begin with, the fact remains that there was no detectable deleterious effect of consuming 56% protein over a 4-year period with a 75% reduction in renal mass. (Performance diets usually have less than 37% protein for extreme situations and less than 32% for most athletic dogs, such as field trial dogs.)

Several other more recent studies have found similar results. Diets with protein levels ranging from 16 to 50% have not had any negative effects on the kidneys.[8] However, dogs that have CRF do ***feel*** worse and show more severe clinical signs when fed high-protein. This is important: healthy dogs can handle protein at any level. Lowering protein intake in normal, healthy dogs is not going to prevent CRF.[9] On the other hand, dogs diagnosed with CRF do need veterinary care and a special diet.

Inherent in all of these protein restriction

studies is the concern that reduced protein intake may result in subtle effects of protein malnutrition: impaired immunological response, reduced hemoglobin production and anemia, decreased plasma protein levels, and muscle wasting.

CONFUSION VERSUS CONTROVERSY

With the evidence failing to support a role of dietary protein restriction in preventing CRF, where is the confusion arising that leads many veterinarians to believe that protein is not only important in the progression of renal disease, but also is a cause? While there is controversy among investigators regarding the level of protein to feed sick patients, there is agreement that protein has no effect on progression of the disease. The confusion may be related to 1) inaccurate use of terms relating to renal failure, 2) lack of clear distinction between renal disease progression and management of the sick CRF patient, and 3) inappropriate application of rat data to the dog. Veterinary medical foods intended for use in dogs with renal failure and the marketing of those foods has placed the protein-restriction hypothesis in front of veterinary practitioners regularly. Some lecturers still speak of managing renal patients with specific low-protein diets to slow the progression of the disease. Furthermore, veterinarians and consumers are incorrectly cautioned that "old" dogs need to be on reduced protein intakes to either prevent the onset of kidney disease or to slow the progression of what might be undetectable renal insufficiency. Neither concept has a basis in fact.

Research conducted by The Iams Company and major universities since 1987 has shown that healthy dogs need normal protein intakes. Diet plays a very important role in managing CRF patients, though. Research has shown that:

- Moderate protein can help properly nourish the patient without causing any problems if a unique fiber blend is added to the diet. This fiber blend helps failing kidneys by trapping metabolic waste products in the feces, which reduces the burden on the kidneys to rid the body of certain metabolic by-products.
- An omega-6 to omega-3 fatty acid ratio of five to one (5:1) can actually help reduce the failing kidney's high blood pressure and slow the progression of the disease.
- Low dietary phosphorus helps the failing kidney (but could be too low for normal dogs)
- Special minerals can help the CRF dog keep the body's acid content from getting too high ("acidosis").

CONCLUSIONS AND RECOMMENDATIONS

With some of the old myths about CRF addressed, attention can be turned to the future. Innovative studies into the roles of common nutrients on renal function will reveal clinically important results. Beneficial effects of protein, phosphorus restriction, and dietary lipids have all been shown. These and other on-going studies will help to more clearly define the role that diet can play in managing renal health in dogs and cats.

In the meantime, some general guidelines for the nutritional management of canine patients are:

- Feed a diet that contains the level of protein appropriate for the dog's activity and balanced to the remainder of the diet
- There is no scientific basis for reducing dietary protein for older dogs
- Dietary protein is not involved in the progression of canine renal disease
- A dog that starts to drink and urinate abnormal volumes should be seen by a veterinarian
- Dogs with renal failure must be managed on an individual basis to control the disease while maintaining nutritional health at the same time; special diets formulated for the CRF patient now make this possible

REFERENCES

1. Osborne CA, Finco DR. Pathophysiology of renal failure and uremia. In: *Canine and Feline Nephrology and Urology*. Baltimore: Williams & Wilkins. 1995.
2. Masoro EJ, Iwaski K, Gleiser CA, et al. Dietary modulations of progression of nephropathy in aging rats: an evaluation of the importance of protein. *Am J Clin Nutr* 1989; 49:1217-1227.
3. Tapp DC, Kobayoshu S, Fernandes S. Protein restriction or calorie restriction? A critical assessment of the influence of

selective calorie restriction on the progression of experimental renal disease. *Semin Nephrol* 1989; 9:343-353.
4. Carey DP. Dietary protein and the kidney. In: Carey DP, Norton SA, Bolser SM, eds. *Recent Advances in Canine and Feline Nutritional Research: Proceedings of the 1996 Iams International Nutrition Symposium*. Wilmington, OH: Orange Frazer Press, 1996; 117-122.
5. Bovee KC, Kronfeld DS, Ramberg C, Goldschmidt M. Long-term measurement of renal function in partially nephrectomized dogs fed 56, 27 or 19% protein. *Invest Urol* 1979; 16:378-384.
6. Finco DR, Brown SA, Crowell WA, et al. Effects of aging and dietary protein intake on uninephrectomized geriatric dogs. *Am J Vet Res* 1994; 55:1282-1290.
7. Brown SA, Finco DR, Crowell WA, Navar LG. Dietary protein intake and the glomerular adaptation to partial nephrectomy in dogs. *J Nutr* 1991; 121:S125-S127.
8. Finco DR, Crowell WA, Barsanti JA. Effects of three diets on dogs with induced chronic renal failure. *Am J Vet Res* 1985; 46:646-652.
9. Finco DR. Effects of protein and phosphorus on the kidneys of dogs. In: Carey DP, Norton SA, Bolser SM, eds. *Recent Advances in Canine and Feline Nutritional Research: Proceedings of the 1996 Iams International Nutrition Symposium*. Wilmington, OH: Orange Frazer Press, 1996; 123-142.

Daniel P. Carey, DVM

Dr. Carey received his Bachelor of Arts degree in Biology from Illinois Wesleyan University in 1973. He continued graduate studies in Biochemistry in 1974 at the University of Missouri-Columbia, where he also received his Doctor of Veterinary Medicine degree in 1978. Dr. Carey has been in private and clinical practice, including three years in the United States Air Force as Base Veterinarian. In 1981 he joined the Ralston-Purina Company and served until 1986 as Manager, Veterinary Services Laboratories and Veterinary Consultant. He joined The Iams Company in 1986 as Manager of Veterinary Services and Regulatory Affairs. He is currently Director of Technical Communications for the Research and Development Division. Dr. Carey has been directly involved in nutrition research on a wide variety of animals. He has experience in clinical, surgical, diagnostic, and nutritional research. He is co-editor of *Recent Advances In Canine and Feline Nutrition*, Vols. 1–3 and co-author of *Canine and Feline Nutrition: A Resource for Companion Animal Professionals*.

Effect of Diet on Hunting Performance

Gary M. Davenport, PhD

INTRODUCTION

Hunting with dogs for sport or in competitive events is a popular pastime in the United States. The breed or type of dog that is used varies with the type of game that is hunted, as well as the terrain and distances that are covered. Regardless of these differences, the work associated with hunting typically involves several hours of endurance activity interrupted by short periods of intense running or sprinting.

The current understanding of the nutritional needs of hunting dogs is based primarily on nutritional studies conducted with racing Greyhounds, endurance sled dogs, or dogs exercising on treadmills in the laboratory setting.[1,2] Much less is known about the nutritional needs of other types of working dogs. These other working dogs include, but are not limited to, those that are used for hunting, herding, obedience competitions, agility events and tracking tests, as well as dogs trained to assist the disabled and military. For each of these categories, the intensity of training and amount of required physical work can vary considerably.

ENERGY NEEDS

Working dogs have increased energy needs compared with the maintenance requirements of normal, adult dogs.[3] At question is the magnitude of this increase, as well as the best way to supply energy and other essential nutrients to support maximum performance and overall well-being of these dogs. There are typically two major nutritional concerns for dogs that are hunted often during a season: 1) feeding to promote optimal performance, and 2) providing enough calories to maintain body weight and body condition. Weight loss is common in dogs that are hunted frequently, especially if weather conditions are harsh. Additionally, warm and humid weather conditions can significantly impact a hunting dog's ability to work and may adversely affect food intake and the ability to fulfill energy requirements.[3]

NUTRITIONAL MANAGEMENT

Nutritional programs for working dogs must be designed to provide ample energy and other nutrients to support muscle contraction during athletic events, while allowing the dog to benefit from training over the course of the season.[4] Both the immediate needs of muscle as well as long-term concerns of aerobic capacity, proneness to injury, and blood volume must be met using an appropriate nutritional strategy.[3] A principal component of this nutritional strategy involves the fulfillment of metabolic energy requirements using dietary sources of fat, protein, and carbohydrates.

Fat

Dietary fat provides the most concentrated form of energy of all the nutrients, is a source of essential fatty acids, and allows the absorption of essential fat-soluble vitamins. The caloric density of dietary fat is more than two-fold greater than protein or carbohydrate sources. Therefore, increasing the level of dietary fat increases the energy density of the diet. Fat also contributes to the palatability and acceptable texture of commercially prepared dog foods. Common sources of fat include chicken fat, tallow, lard, corn oil, safflower oil, soybean oil, sunflower oil, fish oils, and flax oil.

Protein

Dietary protein is supplied by animal and plant sources. In general, high-quality animal-based protein provides superior digestibility, amino acid balance, and palatability. However, the quality of animal-based protein sources can vary depending on processing methods and conditions used during production. Animal-

based protein sources commonly included in commercial dog foods include chicken, chicken by-product meal, chicken meal, beef, egg, fish meal, meat and bone meal, meat by-products, meat meal, lamb, and lamb meal. Common sources of plant-based protein in dog foods include corn gluten meal, soy flour, soy grits, soybean meal, and wheat germ. Lower cost dog foods that are primarily formulated with vegetable protein sources often use a combination of soy products and corn gluten meal to compensate for the low levels of the essential amino acid found in corn gluten (deficient in lysine and tryptophan) and soy products (deficient in methionine).

Carbohydrates

Ingredients that contribute digestible carbohydrates include various forms of corn, rice, wheat, sorghum, barley, potato, and oats. These ingredients contribute complex carbohydrates in the form of starch that is highly available when properly cooked. Other carbohydrate sources include molasses and certain types of hydrolyzed starches. Dietary carbohydrates provide sporting dogs with a readily available source of energy. A limited amount of carbohydrate can also be stored in the body as glycogen with the excess metabolized to fat for energy storage.

A NUTRITIONAL STUDY WITH HUNTING DOGS

Overview of the Study

The nutritional management of hunting dogs can have a significant impact on their overall hunting performance and working ability, based on the results of a 2-year study.[5] Three commercial diets were fed to English Pointers during the quail-hunting season at a hunting plantation in southwest Georgia. Principle ingredients, nutrient content, and caloric distribution of each diet are presented in ***Tables 1*** and ***2***. In the first year of the study, 23 adult Pointers were fed Eukanuba® Adult Premium Performance

Table 1. *Major ingredients of commercial diets fed to English Pointers during the quail hunting season*

EUKANUBA[a]	DIAMOND[b]	PRO PLAN[c]
Chicken	Chicken by-product meal	Chicken
Chicken by-product meal	Ground corn	Corn gluten meal
Corn meal	Wheat flour	Brewers rice
Ground grain sorghum	Chicken fat	Beef tallow
Fish meal	Brewers rice	Ground corn
Chicken fat	Beet pulp	Poultry by-product meal
Ground whole grain barley	Fish meal	Corn bran
Dried beet pulp	Egg product	Animal digest
Natural chicken flavor	Flaxseed	Egg product
Dried egg product	Poultry digest	Minerals and vitamins
Brewers dried yeast	Brewers dried yeast	
Flax meal	Minerals and vitamins	
Minerals and vitamins		

[a] Eukanuba® Adult Premium Performance Formula, The Iams Company, Dayton, OH 45414
[b] Diamond® Premium Adult Dog Food, Diamond Pet Foods, Meta, MO 65058
[c] Purina Pro Plan® Chicken & Rice Dog Performance Formula, Ralston Purina Company, St. Louis, MO 63164

Table 2. *Nutrient content and caloric distribution of commercial diets fed to English Pointers during the quail hunting season.*[a]

NUTRIENT	EUKANUBA	DIAMOND	PRO PLAN
Protein (%)	31.2	26.1	31.9
Fat (%)	21.4	17.2	21.3
Crude fiber (%)	2.1	3.7	2.0
Moisture (%)	6.7	8.3	7.7
Ash (%)	6.6	6.7	5.6
Carbohydrate (%)	31.9	38.0	31.6
Calcium (%)	1.19	1.50	1.30
Phosphorus (%)	0.97	1.07	0.88
Gross energy (kcal/kg)[b]	5,120	4,660	5,139
Metabolizable energy (ME, kcal/kg)[b]	4,220	3,899	4,224
Protein (% of ME calories)[b]	28.1	25.4	28.7
Fat (% of ME calories)[b]	43.1	37.6	42.9
Carbohydrate (% of ME calories)[b]	28.8	37.0	28.4

[a] Nutrient content was determined by laboratory analyses and expressed on an as-fed basis.
[b] Metabolizable energy content and caloric distribution were calculated using the protein, carbohydrate and fat content and the modified Atwater factors (3.8 kcal/kg; 3.8 kcal/kg; 8.5 kcal/kg, respectively).

Formula (Eukanuba) or Diamond® Adult Dog Food (Diamond). In the second year of the study, 22 Pointers were fed Eukanuba or Purina Pro Plan® Chicken & Rice Formula (Pro Plan).

Daily care and management of the dogs was provided by two professional handlers employed by the plantation. These handlers were unaware of the specific diet each dog received during the season. The respective diets were fed exclusively during the training and hunting seasons. Dogs were fed to maintain body weight. The selection of dogs for hunting and the amount of time they were allowed to hunt were at the discretion of the handlers. The handlers recorded the date of hunting, total time hunted, and the number of finds for each dog. Overall hunting performance was calculated for each dog by determining the total number of finds per hunting session and total hours hunted.

Results

The results of year 1 showed that all dogs remained healthy and consumed typical amounts of food throughout the hunting season. Dogs fed Eukanuba maintained or gained weight and body condition throughout the hunting season, while dogs fed Diamond lost significantly more ($P<.05$) body weight and condition ***(Figure 1)***. As a result, body weight and body condition scores at the end of the hunting season were significantly higher for dogs fed Eukanuba compared with those fed Diamond. No significant differences were observed in stool scores, despite a tendency for stools to be slightly softer for dogs fed Diamond.

Dogs fed Eukanuba demonstrated significantly superior hunting performance compared with dogs fed Diamond, based on total finds per hunt and on number of birds located per hour of hunting ***(Figures 2)***. For the season, dogs fed Eukanuba had an average of 55% more finds, which was equivalent to one more find per hour of hunting. There were 9 days during the season in which the heat index was rated as high or severe based on a temperature-humidity index. On each of these days, dogs fed Eukanuba maintained their superior hunting performance, compared with dogs fed Diamond ***(Figure 3)***.

In year 2, there were no differences in body weight, body condition, stool scores or health status for dogs fed Eukanuba or Pro Plan. Despite these similarities, dogs fed Pro Plan required 11% more food to maintain body weight and condition ***(Figure 4)***. This increased feeding amount was equivalent to ⅔ cup more food per day for each dog. Performance results showed that dogs fed Eukanuba had an average of 33% more finds during the season than dogs fed Pro Plan ***(Figure 5)***. Although dogs were not subjected to any heat-stress conditions during this second year, post-hunting rectal temperatures showed that dogs fed Eukanuba ran cooler during hunting compared with dogs fed Pro Plan (***Figure 6***). Body temperature increases during hunting due to increased physical activity. Therefore, the lower post-hunt body temperature of the dogs fed Eukanuba implies that they were more efficient metabolically in capturing dietary energy in a form that could be used to sustain their increased physical activity. In contrast, the higher body temperature of dogs fed Pro Plan implies that less dietary energy was captured in a usable form for work and more was wasted energy lost as heat, which contributed to the increase in body temperature.

Conclusions from the Study

The working ability of English Pointers was measured using the practical response criterion, hunting performance. In terms of the number of points or birds found during a hunting session, the dogs fed Eukanuba performed better than those fed Diamond or Pro Plan. Although such assessments are not easily standardized in a field setting, the two handlers remained unaware of the dietary treatments during both hunting seasons. This control allowed comparisons to be made principally on the dog's hunting success during each season, when the only variation in management was the diet being fed to each group.

Several dietary factors may have influenced the hunting ability and body condition of these dogs. Pointers tend to be a highly active breed and individuals do not typically carry excess body fat. Furthermore, these dogs typically lose a considerable amount of body condition as the hunting season progresses. Weight loss, even when moderate, is always comprised of both fat and lean body tissue.[6] Unfortunately, loss of lean tissue will negatively impact body condition and stamina, which are required for sustained performance as the hunting season progresses.

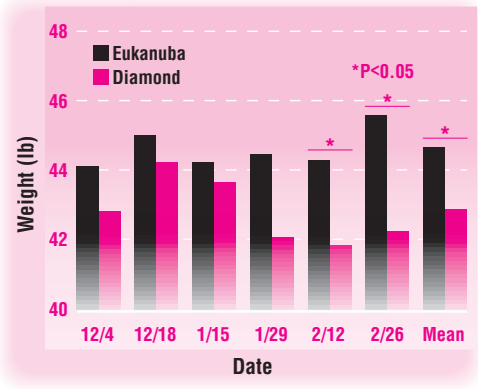

Figure 1. *Body weight of English Pointers fed two commercial diets during quail-hunting season — Year 1.*

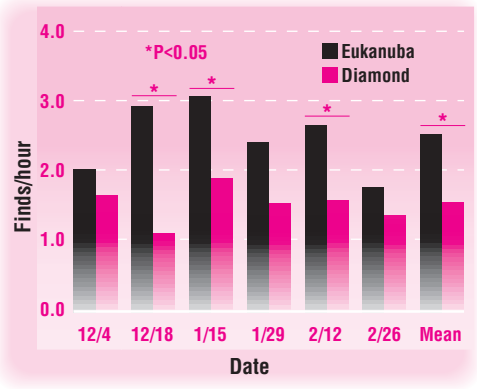

Figure 2. *Hunting performance (finds/hour) by English Pointers fed two commercial diets during quail-hunting season — Year 1.*

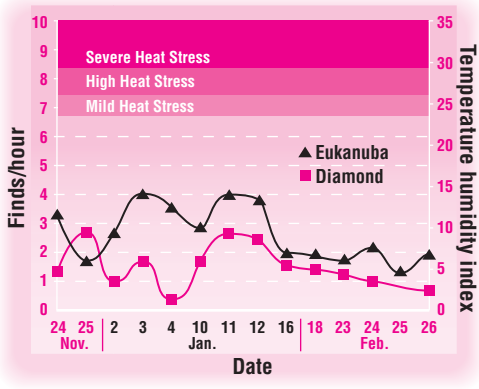

Figure 3. *Hunting performance (finds/hour) of English Pointers during periods of mild to severe heat stress — Year 1.*

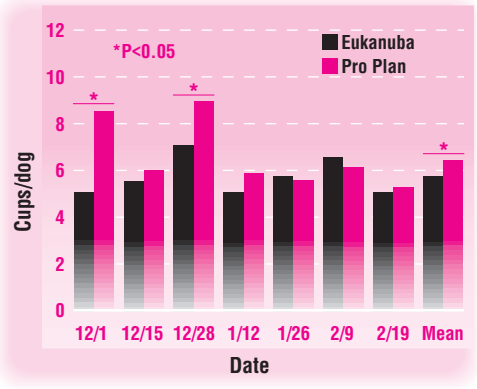

Figure 4. *Daily food intake by English Pointers fed two commercial diets during the quail-hunting season — Year 2.*

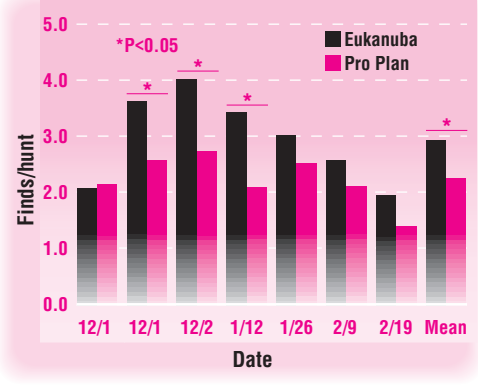

Figure 5. *Hunting performance (finds/hunt) by English Pointers fed two commercial diets during the quail-hunting season — Year 2.*

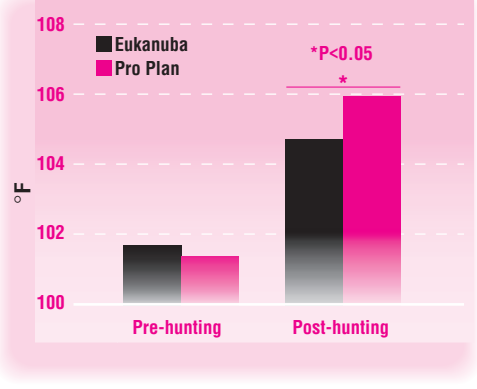

Figure 6. *Pre- and post-hunting body temperatures of dogs fed two commercial diets during the quail-hunting season — Year 2.*

EFFECT OF DIET ON PERFORMANCE

The caloric density of a diet will affect the quantity of food that must be consumed to meet energy requirements. If the energy content of the diet is too low to support increased work, the quantity of food that must be consumed may exceed the physical capacity of the digestive tract. This may lead to an increased rate of passage and decreased diet digestibility, further exacerbating an energy deficit. The production of softer stools implies that a diet may be bulk limiting, which would ultimately affect energy intake, diet digestibility and nutrient availability.

The availability of dietary fat may also affect performance during periods of strenuous work. Dietary fat affects body composition of exercising dogs, as lower fat diets result in a loss of lean tissue and body fat compared with high-fat diets.[7] The dog is an efficient aerobic athlete that performs best when fed a diet that supplies a large proportion of its energy as fat.[8,9] Controlled studies using treadmill-exercised dogs have shown that endurance is positively correlated with dietary fat intake and diet digestibility.[7,10]

In addition, the source of dietary fat may affect hunting ability based on changes in olfactory function. Previous research has shown that olfactory sensitivity is compromised in dogs fed diets containing a greater percentage of saturated fatty acids.[11] Therefore, inferior performance of hunting dogs could be attributed to the source of dietary fat used in commercial dog foods. For example, the use of beef tallow in the Pro Plan formula may have negatively impacted olfactory functionality and hunting performance of the Pointers compared with the performance of dogs fed Eukanuba with poultry fat because the beef tallow provides a greater percentage of saturated fatty acids.

Common folklore among dog trainers asserts that feeding a high-fat diet to working dogs can predispose them to heat stress during hot weather. However, this belief was not supported by the performance data during year 1 of the study. The increased fat consumed by dogs fed Eukanuba compared with Diamond did not negatively affect the working ability or stamina of the dogs during periods of heat stress. These results are also supported by previous research showing that a reduced-fat diet produced higher rectal temperatures in dogs after one hour of treadmill exercise compared with a high-fat diet.[7] Therefore, a high-fat diet appears to be more beneficial to a working dog during periods of hot weather based on its ability to reduce core body temperature. In addition, the source of fat used in the formula may affect thermoregulation based on the lower post-hunting body temperatures of dogs consuming Eukanuba with poultry fat compared to Pro Plan with beef tallow.

Current evidence indicates that aerobic training imposes an increased need for dietary protein in dogs.[12] Athletic conditioning results in adaptive physiological changes that facilitate the efficient delivery of oxygen and nutrients to working muscles. These changes include increases in blood volume, red blood cell mass, capillary density, mitochondrial volume, and the activity and total mass of metabolic enzymes.[11,13] The increased tissue mass and requirement for gluconeogenic amino acids during hunting and exercise necessitate increased protein intake by working dogs. The protein content of the diet may also affect the capacity of blood to oxygenate tissues and transport energy-containing nutrients needed by working muscles.[11] Although the protein content of a diet may be within the recommended range to provide for maintenance needs, a slight reduction in protein content and(or) amino acid availability may become metabolically significant during periods of physical activity due to its inability to supply sufficient amino acids to exercising tissues.

CONCLUSIONS

Dogs are exceptional aerobic athletes, and those trained for endurance events perform best when fed a diet that has been formulated to meet their increased energy and nutrient demands. The results of the plantation study demonstrate that the food selected for working dogs directly affects their performance and working ability, based on the superior hunting performance of dogs fed Eukanuba® Adult Premium Performance Formula compared with Diamond® Adult Dog Food or Purina Pro Plan® Chicken & Rice Formula. These results provide valuable information for trainers, handlers, and

veterinarians who are concerned with the nutritional management of working dogs and the promotion of maximum performance and overall health and well-being.

Permission was granted by Veterinary Learning Systems to reprint portions of this article.

REFERENCES

1. Kronfeld DS. Diet and the performance of racing sled dogs. *J Am Vet Med Assoc* 1973; 162:470-473.
2. Rose RJ, Bloomberg MS. Responses to sprint exercise in the greyhound: Effects on hematology, serum biochemistry and muscle metabolites. *Res Vet Sci* 1989; 47:212-218.
3. Reinhart GA. Nutrition for Sporting Dogs. In: Bloomberg MS, Dee JF, Taylor RA, eds. *Canine Sports Medicine and Surgery*. Philadelphia: WB Saunders, 1998; 348-356.
4. Grandjean D, Paragon BM. Nutrition of racing and working dogs. Part I. Energy metabolism of dogs. *Compendium* 1992; 14:1608-1615.
5. Davenport GM, Kelley RL, Altom EK, Lepine AJ. Effect of diet on hunting performance of English Pointers. *Vet Therap* 2001; 2:10-23.
6. Burgess NS. Effect of a very-low-calorie diet on body composition and resting metabolic rate in obese men and women. *J Amer Diet Assoc* 1991; 91:430-434.
7. Altom E. *Effect of dietary fat and physical conditioning on the metabolic and physiological responses of the canine athlete* [dissertation]. Auburn, AL: Auburn University; 1999.
8. Reynolds AJ, Fuhrer L, Dunlap HL, et al. Lipid metabolite responses to diet and training in sled dogs. *J Nutr* 1994; 124:2754S-2759S.
9. Reynolds AJ, Hoppler H, Reinhart GA. Sled dog endurance: A result of high fat diet or selective breeding? *FASEB* 1995; 9:A996.
10. Downey RL, Kronfeld DS, Banta CA. Diet of beagles affects stamina. *J Am Anim Hosp Assoc* 1980; 16:273-277.
11. Kronfeld DS, Hammel EP, Ramberg CF Jr, et al. Hematological and metabolic responses to training in racing sled dogs fed diets containing medium, low, or zero carbohydrate. *Am J Clin Nutr* 1977; 30:419-430.
12. Adkins TO, Kronfeld DS. Diet of racing sled dogs affects erythrocyte depression by stress. *Can Vet J* 1982; 23:260-263.
13. Querengaesser A, Iben C, Leibetseder J. Blood changes during training and racing in sled dogs. *J Nutr* 1994; 2760S-2764S.

Gary M. Davenport, PhD

Dr. Davenport is an alumnus of the University of Kentucky where he received his BS in Animal Science in 1983, his MS in Ruminant Nutrition in 1985, and his PhD in Nutritional Biochemistry in 1989. Dr. Davenport joined Auburn University in 1989 as an Assistant Professor in the Department of Animal and Dairy Sciences. He was promoted to an Associate Professor in 1995. His teaching and research programs at Auburn University focused on animal nutrition and the relationship between nutrient availability and the hormonal regulation of growth. In 1997, Dr. Davenport accepted a position with The Iams Company in the Research and Development Division where he is currently Principal Research Nutritionist. His current research interests include skin and coat health, protein and amino acid requirements of dogs and cats, and the nutritional needs of sporting dogs. Dr. Davenport has published over 60 scientific papers and abstracts.

Role of Fiber in the Nutrition of the Field Trial Dog

R. Jason Vickers, MS
Gregory D. Sunvold, PhD
Gregory A. Reinhart, PhD

INTRODUCTION

Providing a complete and balanced diet to sporting dogs is essential to support life, maintain health, and provide the nutrients demanded by the body during performance trials. Nutrients in the diet are not only important for maintaining overall health, but can significantly influence the health of the intestinal tract. Research in recent years has shown that the amount and type of dietary fiber that is provided in dog food significantly affects the functioning and health of the intestine and is also relevant to the treatment of certain intestinal disorders. In addition, food intake, nutrient digestion, stool consistency and bulk, excess gas production, and coat quality are directly impacted by fiber type and the amount of fiber present in the diet.

USE OF FIBER IN PET FOODS

To some extent, dietary fiber has always been present in the diet of canines. Both domesticated and wild canines will occasionally consume plant material such as grass, fruits, grains, and at times tree bark; these materials are all sources of fiber. Since commercially processed pet foods were first developed, dietary fiber has been an important dietary component. Pet food manufacturers are required to report the maximum fiber content of the formula on the package label. Listed on the label as percent crude fiber, fiber content in current dog foods ranges from 1% to as much as 30% of the diet.

There are different methods that can be used to calculate the fiber content of pet foods. Although the percent crude fiber (CF) method is typically used to report the fiber content of most commercial products, it generally underestimates the true fiber content. Total dietary fiber (TDF) is another way to determine the fiber content of a diet. The TDF method takes into account the various components of fiber; called fiber fractions, these include cellulose, hemicellulose, lignin, and pectin fiber. The CF calculation method primarily accounts for only cellulose. Where CF content of pet food ranges from 1 to 30%, the TDF content ranges from 5 to 45% and is generally a better indicator of the total fiber content in pet foods.

Cereal grains such as corn, wheat, rice, barley, oats, and sorghum are commonly used in dog foods as carbohydrate sources, but they also contain a considerable amount of fiber. Other supplemental sources of fiber include beet pulp, cellulose, peanut hulls, pea fiber, soybean hulls, and various brans, gums, and pectins. Sources of oligosaccharides, such as fructooligosaccharides (FOS), inulin, and mannanoligosaccharides (MOS), are additional fiber types that are commonly used to promote intestinal health. The amount and type of supplemental fibers can have extensive impact on the health of the dog, especially in the health of sporting dogs.

DIETARY FIBER CATEGORIES

Dietary fiber is plant material that resists digestion by the enzymes present in the intestinal tract, but it can be broken down to varying degrees by bacteria living in the small and large intestine. The major components of dietary fiber include carbohydrates, cellulose, hemicellulose, pectin, gums, mucilages, and lignin.

Fibers can be classified according to their source, solubility, and viscosity characteristics, or the degree to which they are broken down (fermented) by intestinal bacteria. Traditionally, classification of fiber has focused on solubility characteristics that are chemical descriptors, instead of fermentablility that is more important

to the dog's body. While chemical properties allow distinctions to be made, the fermentability of a fiber provides direct evidence of the impact a fiber may have on the intestinal tract. Insoluble fibers have commonly been classified as non-fermentable, while soluble fibers have been classified as fermentable. However, there are notable exceptions to this generalization ***(Table 1)***.

Non-fermentable fiber increases the indigestible bulk of the diet and is of little use to the digestive system. Animal responses to fermentable fiber are typically directly opposite those of non-fermentable fiber. Because the fermentability of a fiber provides direct evidence of its effects within an animal's intestinal tract, this classification scheme is of greatest practical use in canine nutrition.

An important role of fiber in the canine digestive tract is the production of short-chain fatty acids (SCFAs). These natural products of fiber fermentation are very important sources of nutrition for the millions of cells that line the intestinal tract. In fact, 70% of the nutrition for the colon's lining comes from these SCFAs. The cells that line the colon are a vibrant, active, hard-working group of cells. They absorb the nutrients that are so crucial for the competitive field dog, making it very important for these cells to be well-nourished. So, the production of adequate SCFAs is important if the dog is to maintain a healthy intestinal tract.

Extensive research has identified three major categories of fiber. These include fibers that are poorly fermentable, moderately fermentable, and highly fermentable.[1-3] When fibers with low fermentability are exposed to intestinal bacteria, they produce minimal SCFAs, while fibers with high fermentability produce higher amounts of SCFAs. The overproduction or underproduction of SCFAs can have a detrimental impact on the intestinal health of dogs. Examples of poorly fermentable fibers for dogs are cellulose, peanut hulls, and oat fiber. Moderately fermentable sources include beet pulp, rice bran, citrus pulp, gum arabic, gum talha, and carob bean gum. Highly fermentable fiber sources include citrus pectin, lactulose, fructooligosaccharides, and guar gum ***(Table 2)***.

For optimal gut health, a moderately fermentable fiber source, like beet pulp, offers the advantage of producing the most desirable level of SCFAs to minimize constipation or excess gas production, while providing ideal nutrition for the cells that line the intestine.

EFFECTS OF FIBER ON CANINE HEALTH

Food Intake and Passage

Whether it is a Beagle tracking rabbits or a Labrador retrieving waterfowl, adequate food intake of a nutritionally balanced diet is a must. A popular theory about fiber is that its inclusion in a diet causes increased feelings of satiety (hunger satisfaction) and decreased intake of calories. This effect is presumed to be due to the

Table 1. *Dietary fiber fermentation in dogs*

FIBER SOURCE	SOLUBILITY	FERMENTABILITY
Beet pulp	Low	Moderate
Cellulose	Low	Low
Rice bran	Low	Moderate
Gum arabic	High	Moderate
Pectin	High	High
Carboxymethylcellulose	High	Low
Methylcellulose	High	Low
Cabbage fiber	Low	High
Guar gum	High	High
Locust bean gum	High	Low
Xanthan gum	High	Low

Table 2. *Fermentation index of several dietary fiber sources for dogs*

FIBER SOURCE	CANINE FERMENTATION INDEX*
Cellullose	0.2
Oat fiber	0.4
Gum karaya	0.6
Peanut hulls	0.9
Xanthan gum	1.0
Gum arabic	1.0
Gum talha	1.3
Psyllium gum	1.4
Soy hulls	1.4
Rice bran	1.8
Beet pulp	2.5
Carob bean gum	3.4
Citrus pulp	3.4
Locust bean gum	5.3
Fructooligosaccharides (FOS)	5.7
Citrus pectin	5.9
Guar gum	7.3
Lactulose	8.3

*Total SCFA production after 24 hours of fermentation (mmol/g of substrate organic matter [OM])

physical bulk of fiber and the diluting effect it has on a diet's caloric density. A well-established effect of dietary fiber is its influence upon the rate of passage of food through the intestinal tract. In dogs, moderately fermentable fibers such as beet pulp result in a shorter intestinal transit time, where diets containing non-fermentable fiber such as cellulose have longer transit times.[1]

Although not scientifically proven, longer transit times may result in decreased food intake. Decreased food intake will limit the amount of energy and nutrients available to the dog and may lead to decreased activity. In the case of the hunting or field trial dog, frequent consumption of a well-balanced diet is necessary to supply the increased demands for energy and essential nutrients that competition or hard work might require. Handlers and trainers are often challenged to keep their dogs' appetites within normal limits, even if they are healthy. It would be counterproductive to provide a food that might decrease quantity because of a less than optimal fiber source. Diets containing appropriate levels of moderately fermentable fibers will allow for optimal food intake and food passage.

Nutrient Digestion and Absorption

A premium dog food should provide the intestine with the substrates necessary to maintain normal intestinal function, digestion, and nutrient absorption. The type and amount of fiber can significantly affect a diet's digestibility. In the sporting dog, high levels (greater than 5% CF or 14% TDF) of poorly fermentable fiber such as cellulose, peanut hulls, or oat fiber can dramatically decrease nutrient digestion and absorption. These types of fibers tend to be viscous in nature, possibly resulting in decreased protein and fat digestibility, the binding of key nutrients such as vitamins and minerals, and the subsequent decrease in the overall availability of nutrients to the dog. Sufficiently lowered nutrient availability will result in decreased energy and performance. Products containing reasonable levels (up to 5% CF or 14% TDF) of beet pulp, rice bran, and other moderately fermentable fibers will not only help to maintain nutrient digestibility, but also can increase absorption of vital nutrients. Fermentable fibers will help "feed the gut", thereby increasing absorptive surface area and allowing for increased nutrient uptake.

SCFA Production

As outlined above, another characteristic of fiber is the amount and type of short-chain fatty acids that are produced by intestinal bacteria during fermentation. The SCFAs, which include acetate, propionate, and butyrate, are major end-products of bacterial fermentation and are important contributors to many documented benefits of fermentable fiber ***(Figure 1)***. Intestinal cells have a very high replacement rate that in turn increases the demand for energy. Short-chain fatty acids, specifically butyrate, provide a significant proportion of intestinal cell energy requirements of the dog.[2,3] When dogs are fed diets that contain non-fermentable fiber sources, such as cellulose, SCFA production is minimal and the energy required for intestinal maintenance will be pulled from the other energy sources. This will result in a decrease in available energy for other normal body functions.

Providing the intestine with adequate levels of readily available energy sources, such as SCFAs, will promote the growth of new intestinal cells. In addition, feeding diets that contain moderately fermentable fibers may actually increase the tissue quantity of the colon and increase intestinal surface area, when compared to diets containing a non-fermentable fiber source.[4-6] These are signs of a healthy digestive tract that will help support the intense lifestyle of the competitive dog.

Increased growth of intestinal cells, increased colon tissue, and increased intestinal surface area provide the environment favorable for improved nutrient absorption. On the other hand, highly fermentable fibers result in the production of excessive amounts of SCFA that may cause undesirable side effects such as loose stools and excess gas. It is very important that a diet contains the appropriate type and level of fermentable fiber in order to avoid these extreme effects.

Fecal Volume and Consistency

One of the most important characteristics of a food for the large sporting dog kennel is the stool quality it produces. Stool quality can be significantly affected by dietary fiber. Liquid feces, diarrhea, and constipation are all undesirables

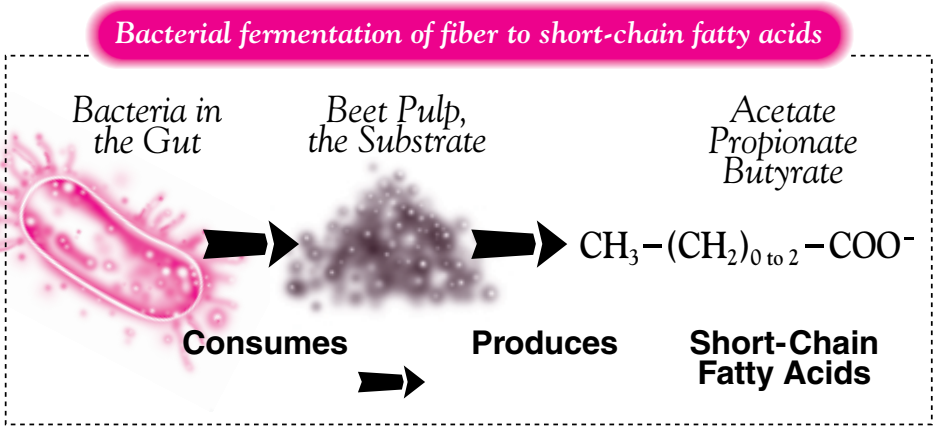

Figure 1.

in sporting dogs. Optimal stool quality is defined as having an adequate firmness to prevent diarrhea, but soft enough to prevent constipation. These characteristics are usually found when the stool is approximately 25–35% dry matter (65–75% moisture).

Feeding highly fermentable fibers (pectin, carob bean gum, and locust bean gum) results in liquid, unformed stools and undesirable gas production in dogs.[1] In contrast, feeding fiber sources that are low in fermentability (such as cellulose) results in decreased defecation frequency, decreased fecal moisture content, and hard, dry feces. Diets containing a large amount of cellulose or similar fibers can also result in excessive stool volume. Feeding a premium dog food that includes a moderately fermentable fiber, such as beet pulp, results in moist, well-formed stools and nominal fecal output. Moderately fermentable fibers provide the physical benefits of bulk and tactile stimulation within the intestinal tract that facilitates the production of ideal stools.

ROLE OF FIBER IN CONTROLLING INTESTINAL DISORDERS

Diarrhea

Because the type of fiber in the diet influences the amount of water that is retained in feces, modifying the source of dietary fiber is often an effective means of nutritionally managing diarrhea in dogs. Feeding moderately fermentable fibers, such as beet pulp and rice bran, results in stools that have optimal form and consistency, but which still contain a relatively high amount of moisture (65% or greater).[1] In contrast, poorly fermented fiber sources such as cellulose result in low water content in feces and the production of dry and hard stools. Diets that contain excessive amounts of highly fermentable fibers are not recommended for dogs with diarrhea because of their tendency to produce loose stools or make the incidents of diarrhea worse.

A common problem that owners and trainers of field dogs observe is the occurrence of stress-induced diarrhea. Environmental factors such as exposure to new surroundings, other animals, and general excitement can periodically result in loose stools. It is not unusual to see this condition as competitive dogs approach their time to perform. The stress of the breakaway in bird dog trials is a classic example. Depending on the prevalence and frequency of diarrhea episodes, the cost associated with treatment of the disorder, as well as the additional labor required for animal care and facility maintenance, can be significant. To better understand the role that nutrition plays in controlling these periodic episodes of diarrhea a research study was recently conducted.

Two veterinary diets that were formulated to maintain intestinal health were evaluated for their ability to control stress-associated diarrhea. Diet 1 contained a blend of fermentable fibers including beet pulp and FOS, while Diet 2 contained only soy fiber. Twenty dogs housed in a kennel environment were identified with stress diarrhea and were randomly assigned to either

Diet 1 or Diet 2. No medical treatment was administered to the dogs during the trial. Dogs were monitored for 10 days.

An improvement in stool consistency was observed in dogs consuming Diet 1, with the blend of fermentable fiber, after only 3 days; diarrhea resolved after only 8 days ***(Figure 2)***. An improvement in stool consistency was not observed until day 6 in dogs consuming Diet 2, the soy-fiber diet. In addition, diarrhea did not resolve during the 10-day period of consuming the soy-fiber diet.

The results of this study indicate that diets containing fermentable fibers are more effective in controlling bouts of intestinal upset, even without the intervention of any medical treatment such as parasitic agents, antibiotics, or anti-diarrhea agents. By decreasing the intensity and duration of diarrhea episodes through nutritional management, a substantial cost savings can be realized. In addition, feeding diets that contain fermentable fibers promotes intestinal health, making it a great way to decrease the risk of diarrhea.

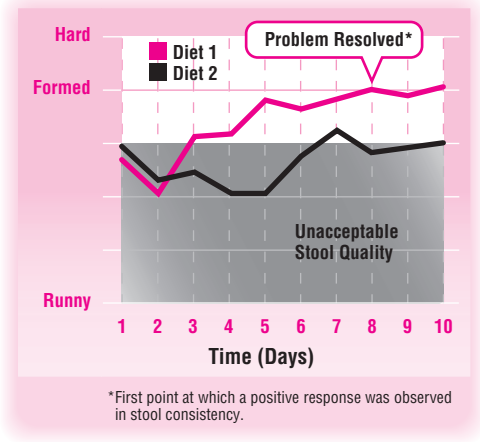

Figure 2. *Average daily stool scores of dogs consuming fermentable (Diet 1) and non-fermentable (Diet 2) fiber.*

Constipation

Equally serious as diarrhea is constipation in sporting dogs. Any time that the body has an increased demand for water, the threat of constipation is present. In periods of dehydration, the body will pull available water from any and all bodily locations, including the intestine. During training or hunting, the sporting dog has an increased demand for water, which may result in the development of dry, hard stool that may be difficult to pass. This phenomenon may be exaggerated when diets with non-fermentable fiber are fed, since these fiber types will commonly result in the production of dry, hard feces.

Including moderate amounts of fermentable fiber in the diet of sporting dogs will help alleviate this problem for multiple reasons. First, fermentable fibers have a higher water-binding capacity than non-fermentable fibers. This characteristic results in the production of more ideal stools with higher moisture content, making the stool easier to pass. Secondly, fermentable fibers help maintain normal intestinal transit times, thereby preventing abnormal removal of water from the intestine. Both of these factors will aid in the production of normal stools in highly active as well as normally active canines.

Intestinal Bacteria

In the past, it was common for veterinarians to treat intestinal diseases caused by bacteria through the administration of antibiotics. While this method may be effective in certain cases, a side effect of this therapy can be the development of antibiotic-resistant strains of intestinal bacteria. Alternatively, a treatment can be utilized that works with the existing gut flora (bacteria) and change it in a way that is more favorable to the host animal. This is made possible by the "prebiotic" effect of certain fibers.

A prebiotic is simply a substance that can be used as a food source by a bacterium. Fiber sources such as FOS may be beneficial, since they selectively promote the growth of beneficial bacteria such as lactobacilli, at the expense of bacteria such as Clostridia and *E. coli*, which can produce disease. The use of prebiotics can help promote favorable gut bacteria.

Bloat

Bloat is the common term for gastric dilatation and volvulus syndrome (GDV). The condition is serious because the stomach enlarges and may twist around on itself, which can lead to a life-threatening situation. Despite many research projects and studies, the exact cause of bloat remains unknown. It does occur more commonly in large, deep-chested dogs

which reflect several sporting breeds. Typical signs are wretching, swollen belly, drooling, and pacing. If these signs are noted, an immediate trip to the veterinarian is in order.

The incidence of bloat in sporting dogs has not been reported. However, it occurs regularly in large sporting breeds and under some circumstances, can result in death. A recent study indicated that approximately 10% of military working dogs between 1993 and 1996 died or were euthanized due to severe complications resulting from bloat.[7] Although a direct correlation between fiber type and the incidence of bloat has yet to be established, it stands to reason that fiber might play a role in this disorder.

Viscous non-fermentable fiber types such as cellulose may further complicate cases of bloat as intestinal transit of food particles is slowed. This may hinder the release of gases as the slowly moving digestive material prevents gas buildup from escaping. Highly fermentable fiber types such as citrus pectin and guar gum may result in increased gas production that would also intensify periods of bloating. As previously suggested, feeding non-viscous, moderately fermentable fibers will help to maintain normal rates of food passage with minimal gas production, which should minimize the risk of bloat.

FEEDING RECOMMENDATIONS

Given the diverse physiological effects of different fibers, the formulation of diets for healthy dogs must incorporate appropriate levels and sources of this nutrient. Feeding moderately fermentable fiber to healthy dogs promotes appropriate food intake and passage, ideal nutrient digestibility and absorption, the production of short-chain fatty acids, and ideal fecal consistency and volume. Diets containing fermentable fiber also can aid in managing diarrhea, constipation, intestinal bacteria, and possibly bloat.

- All Eukanuba® and Iams® dog food formulas contain beet pulp, a moderately fermentable fiber source.
- During periods of normal activity, when the energy demands of the field trial dog are lower, Eukanuba® Adult Maintenance Formula or Iams Chunks® or Iams MiniChunks® are highly recommended. These foods provide the essential nutrients for whole body health and fermentable fiber for intestinal health.
- During periods of high activity, Eukanuba® Adult Premium Performance Formula is recommended. This nutrient dense formula can meet the dog's increased demands for energy as well as provide the associated intestinal health benefits observed from the inclusion of beet pulp.
- For those dogs with diarrhea, constipation, or other intestinal conditions, the kennel veterinarian can prescribe Eukanuba Veterinary Diets® Nutritional Intestinal Formula™ Low-Residue™ with beet pulp and FOS. This diet, while only available from your veterinarian, is an excellent choice for dogs that experience periods of stress diarrhea sometimes associated with the excitement prior to a sporting event. The Low-Residue™ formula can also be fed to normally active dogs to provide essential nutrients as well as minimize the risk of diarrhea.

REFERENCES

1. Sunvold GD, Fahey Jr GC, Merchen NR, Titgemeyer EC, Bourquin LD, Bauer LL, Reinhart GA. Dietary fiber for dogs: IV. In vitro fermentation of selected fiber sources by dog fecal inoculum and in vivo digestion and metabolism of fiber-supplemented diets. *J Anim Sci* 1995; 73:1099-1119.
2. Sunvold GD, Fahey Jr GC, Merchen NR, Reinhart GA. In vitro fermentation of selected fibrous substrates by dog and cat fecal inoculum: Influence of diet composition on substrate organic matter disappearance and short-chain fatty acid production. *J Anim Sci* 1995; 73:1110-1122.
3. Sunvold GD, Hussein HS, Fahey Jr GC, Merchen NR, Reinhart GA. In vitro fermentation of Solca Floc®, beet pulp, citrus pulp, and citrus pectin using fecal inoculum from cats, dogs, horses, humans, and pigs and ruminal fluid from cattle. *J Anim Sci* 1995; 73:3639-3648.
4. Hallman JE, Moxley RA, Reinhart GA, Wallace GA, Clemens ET. Cellulose, beet pulp, and pectin/gum arabic effects on canine microstructure and histopathology. *Vet Clin Nutr* 1995; 2:137-142.
5. Hallman JE, Reinhart GA, Wallace EA, Milliken A, Clemens ET. Colonic mucosal tissue energetics and electrolyte transport in dogs fed cellulose, beet pulp or pectin/gum arabic as their primary fiber source. *Nutr Res* 1996; 16:303-313.

6. Clemens ET. Dietary fiber and colonic morphology. In: Carey DP, Norton SA, Bolser SM, eds. *Recent Advances in Canine and Feline Nutritional Research: Proceedings of the 1996 Iams International Nutrition Symposium*. Wilmington: Orange Frazer Press, 1996; 25-32.
7. Moore GE, Burkman KD, Carter MN, Peterson MR. Causes of death or reasons for euthanasia in military working dogs: 927 cases (1993–1996). *JAVMA* 2001; 219:209-214.

R. Jason Vickers, MS

Jason Vickers received his Bachelor of Science degree in Animal Science in 1996 and Master of Science in Non-Ruminant Nutrition in 1998 from The University of Tennessee, Knoxville. The title of his MS thesis was "The Effect of Volatile Fatty Acid Inclusion in Drinking Water on Intestinal Microflora, VFA, pH, Dry Matter, and Performance in Weanling Pigs". In October of 1998, Mr. Vickers joined the strategic research group in the Research and Development Division of The Iams Company where he is currently Associate Research Scientist. His research focus includes the areas of gastrointestinal health, obesity, and diabetes as well as the clinical application of innovations within these areas. Special research interests include studying the role of prebiotics in maintaining and enhancing the health of the dog and cat.

Nutritional Influences on Dental Health in the Field Dog

Edward R. Cox, BS
Allan J. Lepine, PhD

INTRODUCTION

Although veterinary dentistry is a relatively new specialty, dental disease is one of the most common problems affecting companion and hunting dogs and has been recognized for over 70 years. For example, Talbot reported in 1899 that periodontal disease affected 75% of dogs between 4 and 8 years of age.[1] This incidence has been subsequently confirmed in a recent review identifying 53 to 95% of dogs older than one year of age as having some degree of periodontitis.[1] The widespread nature of dental concerns in the dog mandate that awareness of the problem be increased in sporting dog owners and potentially beneficial strategies be explored that are applicable in the field trial or hunting kennel.

DENTAL DISEASE

Periodontal disease, while a very common problem, is often a very loosely applied term. It is regularly used in a generic manner to include non-periodontal conditions such as gingivitis. In actuality, it is defined as "disease of the supporting structures of the teeth."[2] These supporting structures serve to hold the teeth firmly in the jaws and act as a shock absorber, allowing for tearing and grinding of food without damage to the teeth or the bone that surrounds the teeth. The periodontal structures consist of the periodontal ligament (connective tissue between the root of the tooth and the socket), the gums, cementum, and bone. Progressive damage to the supporting structures of the teeth can result in pain, and ultimately, tooth loss. This can lead to decreased performance in the field due to discomfort or poor condition.

The initial step in the progression towards periodontal disease is the formation and accumulation of plaque on the tooth surface. Any clean tooth ***(Figure 1)***, when exposed to saliva, immediately develops a sugar-protein layer referred to as the pellicle. Normal oral bacteria adhere to this pellicle and begin to multiply. The addition of food particles, sloughed epithelial cells and saliva to the pellicle forms dental plaque ***(Figure 2)***. It is often referred to as a biofilm, made up largely of bacteria.[1,3,4] Plaque forms very quickly in humans and animals, typically within hours of a dental cleaning by the veterinarian or dentist. Dental plaque is a soft material, but movement of the tongue, drinking water or saliva cannot remove it. It can, however, be removed by physical abrasion such as that occurring during brushing of the teeth or chewing.

Plaque that is not removed can eventually be converted to dental calculus, also called tartar. Formation of tartar from plaque occurs when mineral salts in the saliva, such as calcium carbonate and calcium phosphate, precipitate out and are deposited in the plaque. The deposition of calcium typically occurs in and between bacterial remains present in the plaque. Dental tartar is a very hard deposit that is strongly adhered to the tooth. It can be seen both above and below the gum line and is recognized as the hard, brown build-up near the gum line. Once formed, tartar can only be adequately removed by a professional dental prophylaxis.

Risk Factors for Dental Disease

Numerous studies have shown periodontal disease as the most common diagnosis in companion and field dogs. Many of these same studies have also documented a strong correlation between increased age and increased prevalence of dental disease. These increases range from 66% to over 80% in dogs older than 6 years of age.[1] Eisner suggested that stresses, including advanced age, may compromise host defense

systems in the oral cavity.[3] Another study conducted in Japan with 251 dogs demonstrated a significant correlation between greater dental tartar and increased age.[5] Results also indicated a higher prevalence of periodontitis associated with aging dogs.

Good oral hygiene becomes more difficult when teeth are deformed as in overbites, undershots, or poor alignment of the molars. These problems provide areas on teeth where plaque can form and tartar can deposit. The increased deposition of tartar and incidence of periodontal disease as age increases is further complicated by the fact that the likelihood of additional underlying health conditions increases as the animal ages. Therefore, risks associated with dental prophylaxis (ie, anesthesia) may also increase with increasing age.

CONSEQUENCES OF POOR ORAL HYGIENE

Although tartar is primarily a cosmetic problem, it is indicative of the need for dental hygiene. Generally, this need is initially manifested visually as accumulation of tartar and (or) olfactorally as breath malodor. Breath malodor is primarily caused by bacterial metabolism of proteins in the oral cavity. Proteins are readily available in the oral cavity from food debris, saliva, epithelial cells, and blood. The presence of plaque and tartar provides a favorable environment for bacterial proliferation and further metabolism of proteins leading to continued malodor. Breath malodor is typically associated with gingivitis and periodontitis.

Severe gingivitis, periodontitis, and tartar accumulation can lead to poor scenting in the field dog.[6] If periodontitis becomes severe enough, it can inflame the trigeminal nerve which carries the message of scent to the brain. Also, excess odor from the mouth can overwhelm the faint scent of game thereby resulting in decreased field trial performance.[6]

Dental tartar, if left untreated, can lead to even more buildup of the hard, brown substance on the teeth. The surface of dental tartar is rough, which allows for further accumulation of plaque on top of existing tartar. Maturation of this newly deposited plaque continues the process of tartar buildup on the teeth. As tartar continues to accumulate and extend into the gum pocket, the rough surface irritates the gums, causing inflammation of the soft tissues ***(Figure 3)***. Inflammation from bacterial toxins in plaque plus physical irritation from this tartar under the gums leads to inflammation of the gum tissue. The edges of the gums may begin to look red and mildly swollen. Although gingivitis is a completely reversible condition, it can become chronic if the teeth are not cleaned.

Without proper dental cleanings, bacteria can be trapped under a swollen gum line resulting in bacterial toxin and white blood cell accumulation and further tissue damage. The tissue under the gums eventually becomes a periodontal pocket, resulting in an oxygen-depleted environment. Complex destructive anaerobic bacteria begin to predominate in this environment, leading to further release of toxins and continuation of the dog's inflammatory response. It is important to note that bacteria do not directly cause the tissue damage in periodontal disease. Rather, it is the dog's immune system attempting to control the infection and inflammation that contributes to actual damage to the tissues. Once plaque and the resultant inflammation reach the periodontal ligament, damage to this anchoring structure can occur and periodontal disease is initiated ***(Figure 4)***.

Damage to the periodontal ligament is irreversible. As the disease progresses, bone erodes causing the tooth to loosen and be lost. This process of bone loss occurs over a prolonged period of time. Periodontal disease goes through active periods of tissue damage followed by quiet periods of inactivity and healing. Untreated periodontal disease may take as long as two to five years before enough of the bone is destroyed to cause tooth loss.[3,4] It is often a silent disease that may progress without obvious clinical signs, even in the face of severe disease. Clinical signs of periodontal disease made include any or all of the following[7]:

- Halitosis
- Anorexia
- Difficulty eating
- Ptyalism (chronic drooling)
- Head shaking
- Behavioral changes
- Red, swollen, and/or bleeding gums
- Loose teeth
- Poor scenting ability
- Accumulation of plaque, tartar, and stain
- Ulcerations on gums or oral mucosa

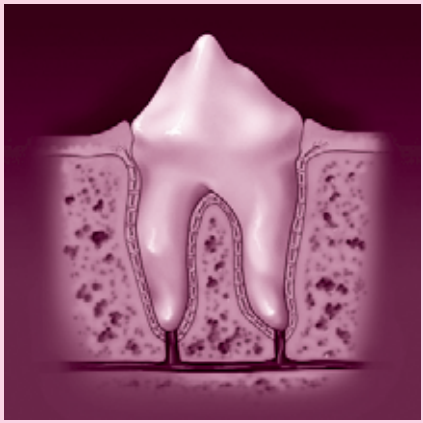

Figure 1. *Example of a clean, healthy tooth.*

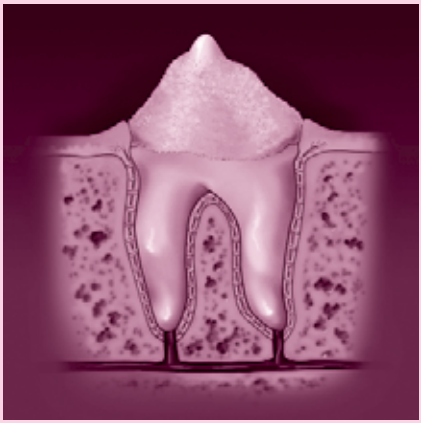

Figure 2. *The initial step in the progression towards periodontal disease is the formation and accumulation of plaque, a soft biofilm, on the tooth surface.*

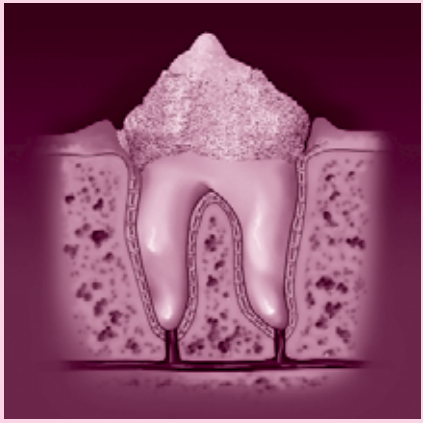

Figure 3. *As tartar continues to accumulate and extend into the gum pocket, the rough surface irritates the gums and causes inflammation of the soft tissues.*

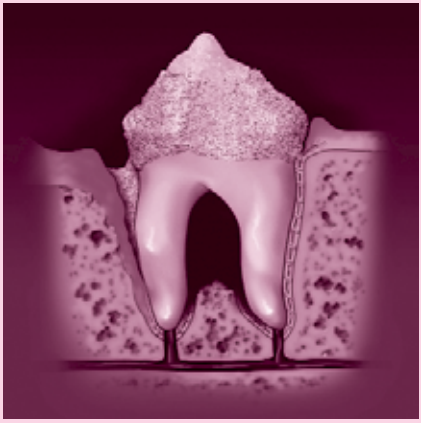

Figure 4. *This tooth has advanced periodontal disease as plaque and the inflammation now extends into the periodontal ligament. Damage to the periodontal ligament is irreversible; loss of the tooth is inevitable.*

Dental Disease and Its Effects on Systemic Disease

There has been much speculation by veterinarians about the correlation between periodontal disease and other health problems in performance dogs. Since periodontal disease is the most common disease affecting dogs, concern is certainly warranted. Furthermore, dental disease is more common and often more severe in older animals who may also have compromised immune systems and other underlying diseases of the heart, lungs or kidneys. Diabetes has been linked to increased periodontal disease in humans but the same evidence is not present in dogs.[4] Several authors have cited existing evidence in the human literature regarding dental disease and the risk of heart disease, pulmonary infection, stroke, and low birth weight babies.[7,8] It has been noted that bacteria in the blood occurs in some dogs and cats with dental disease, increasing after dental manipulation.[1,7] Healthy animals should be able to clear a transient level of bacteria in the blood, but there may be cause for concern in dogs under stress (such as during hunting), dogs with compromised immune or organ function, and in older animals.

In addition to bacteria in the blood, local host inflammatory responses to periodontal disease produce inflammatory chemicals. Since periodontal tissue is not walled off from the rest of the body, these chemicals (called cytokines) may reach the general circulation. It is possible that the concentration of cytokines may be high enough to produce systemic effects. One more recent study by DeBowes et al.[8] demonstrated a correlation between the severity of periodontal disease in dogs and histologic changes in the heart muscle, kidney, and liver tissues. Additional research is required to determine if periodontal disease is a risk factor for systemic diseases in the dog.

ORAL HEALTH CARE STRATEGIES

Virtually all veterinarians agree that the single best oral health care strategy is prevention. Prevention is less costly for clients and is safer for the animal. Regular professional dental prophylaxis combined with diligent home care is the key to healthy teeth and gums. Once dental disease has progressed beyond mild gingivitis, longer anesthetic times and more advanced procedures are necessary, increasing the cost to the client and stress to the animal.

Dental Prophylaxis

A dental prophylaxis consists of several components. A complete oral examination, oral charting, scaling, and polishing of the crown and subgingival surfaces. Necessary equipment includes hand scalers, a power scaler, curettes, and polishing equipment. For dogs, it is also recommended to use a preoperative rinse of dilute chlorhexidine solution to help minimize the bacteremia that occurs during a dental cleaning.[9] Power scaling should be used first, followed by hand scaling to gently remove residual plaque and tartar under the gumline. Polishing is recommended after planing and scaling to smooth enamel grooves and pits that occur from scaling. Lastly, flushing under the gums and outside the gums removes residual pumice from polishing, which can act as an irritant to the gums.

Dental Care in the Kennel

Although periodic professional dental prophylaxis is very important to periodontal health, the importance of kennel care must be emphasized. During the past several years, there has been a dramatic expansion of dental products designed to make home and kennel dental care easier for the owner and more tolerable for the sporting dog. Veterinarians agree that brushing the teeth remains the most effective means for removing plaque and preventing gingivitis. Despite the difficulty in brushing the teeth of a large number of dogs in a hunting or field trial kennel, this still is the best single step a kennel manager can take to prevent dental and gum disease. DuPont reported that tooth brushing three times weekly can prevent gingivitis in dogs.[9]

Pet toothbrushes come in a variety of sizes and shapes to improve the efficiency of brushing. Finger brushes are available although some veterinarians feel that the bristles are too soft to effectively remove plaque.[9,10] They can, however, be used as a transition to a toothbrush. Toothpastes are available that are specifically designed for dogs. Toothpaste facilitates plaque removal but effective brushing can be obtained without it. Other products are available that aid in plaque control, such as enzymes glucose oxidase and lactoperoxidase, which have antimicrobial activity and have been incorporated into some pet toothpastes. Chlorhexidine and zinc ascorbate are also available in topical gels or rinses.

Despite the benefits of brushing, it can be difficult in large kennels. While it is best to schedule a regular brushing of each dog's teeth, this is too time consuming and labor intensive. Still, this approach can yield benefits in lowered costs of professional care, upgraded oral health of valuable dogs, and less side effects of dental disease. Despite the apparent impracticality of home and kennel dental care, it still must be recommended for optimal prevention of dental disease even in the large training or breeding kennel.

NUTRITIONAL ORAL HEALTH CARE

Daily brushing will help remove plaque and prevent the formation of tartar, gingivitis, and periodontal disease. However, compliance to this aggressive brushing schedule is difficult in the typical field trial or hunting dog kennel. Many veterinarians recognize that once yearly professional dental prophylaxis without home care will not effectively prevent periodontal disease.[10] In recent years, an increasing number

of nutritional products have become available that can act as adjuncts to professional and home dental care. These products offer many advantages to the large hunting, field trial, and breeding kennel. They primarily rely on mechanical scraping to remove plaque from the teeth. They may help remove some plaque, but there are limitations to this strategy.

There is a long held belief that dry diets reduce the rate of plaque accumulation and gingivitis in dogs and cats exclusively fed wet food. A review of the literature by O'Rourke[11] concluded that there was evidence to suggest dry food maintained the health of the gums, periodontal membrane, and bone adjacent to the teeth. A study by Burwasser and Hill[12] demonstrated that dogs fed soft diets tended to produce pathological changes in the gums as seen microscopically. Egelberg conducted a study measuring plaque formation and the amount of gum exudate (pus) in 14 dogs fed dry or soft diets.[13] Dogs fed the wet diet accumulated more plaque and developed more gingivitis than when they were fed the dry diet. However, a more recent study by Harvey et al.[14] involving 1,350 dogs did not find a significant protective effect in dogs fed dry food versus those fed semi-moist or wet food. All owners and trainers of sporting dogs and hounds know that dry food alone will not prevent tartar formation in all dogs and the effect of hard food on dental health may vary according to the individual animal.

Reduced tartar, gum disease, and bone loss has been reported in dogs that chew on various items (toys, rawhides, and biscuits) compared to those dogs that had little or no access to these materials.[15] Rawhide chews were found to have a greater effect as compared to biscuits or toys. Interestingly, the greatest protective effect on periodontal tissues was found in dogs that were fed hard food and chewed rawhide treats. While these items may present a problem in large kennels, home raised sporting dogs may benefit. In fact, the use of such chew devices, even in the sporting dog kennel may be worth the effort. Another study by Lage et al.[16] reported that rawhide chews removed more tartar from dog teeth compared to cereal biscuits. The influence of other types of chews on plaque, tartar, and gingivitis has been investigated as well. One study involving a flexible urethane bone found less supragingival tartar in dogs after 30 days of use compared to those that did not have the bone.[17] Another chew developed for dental health was the subject of two studies. Both found that adding the chew to a dry diet decreased tartar, plaque, and the incidence and severity of gingivitis in dogs after three or four weeks.[18,19]

The introduction of several nutritionally complete diets formulated to improve oral health has occurred over the last several years. The standard strategy involves using mechanical scraping action to clean the teeth. This primarily has been achieved by changing the texture and size of the kibble. These changes are claimed to increase and prolong the chewing action by the pet. While the pet chews the food, it is purported that plaque and tartar are scraped off the surface of the teeth. Additives in some diets, such as alfalfa meal and cranberry extract are alleged to have antibacterial effects for reduction of breath malodor.

Despite reports of plaque and tartar removal by standard dental products, there are limitations to this strategy. Mechanical abrasion from hard food, chews, and specialized diets will only occur where the food actually contacts the tooth surface. Uniform results will not be obtained on all teeth and may be particularly hindered in animals with malocclusion. Additionally, the physical abrasive action can only occur while the dog or cat is actually chewing the product. There is no continued effect on the teeth once the product is swallowed, between meals or between chewing sessions. Effectiveness will also be decreased in dogs or cats that tend to swallow with little or no chewing action. In addition, some of these products are "dental only" thereby making them of minimal use in a sporting dog kennel where high-energy performance nutrition is considered a necessity for optimal execution at field trials or while hunting.

NOVEL NUTRITIONAL APPROACH TO CONTROLLING DENTAL TARTAR

A new approach to preventing tartar formation is to utilize nutritional mineral sources to provide dental benefits. Specifically, nutritional sources of phosphates can be manipulated during manufacturing to enhance the physical properties of the kibble without altering the

base formula, or kibble size. This is accomplished via a unique manufacturing process that coats the polyphosphates on the outer surface of the food in a microcrystalline form.

The polyphosphate crystals help to prevent the mineralization of plaque into tartar by forming a physical barrier on the plaque surface. This is in contrast to current methodologies that utilize abrasion to remove plaque during chewing. The benefit of the barrier approach is that polyphosphates can provide whole mouth benefits as they release from the diet during mastication and carry throughout the oral cavity. This mechanism of action—called the Eukanuba Dental Defense System™—allows the polyphosphates to provide benefits to non-chewing surfaces as well as contact surfaces. Additionally, this nutritional approach offers a prolonged dental benefit as the polyphosphates remain within the plaque until the body absorbs them as phosphorus nutrients.

EFFECTS OF PHOSPHORUS SOURCES ON DENTAL HEALTH

Studies were conducted on both canines and felines to test if nutritional sources of phosphate could be utilized to improve dental health. The studies were of a crossover design, and utilized the guidelines set forth by the Veterinary Oral Health Council (VOHC) for determining dental benefits. In all studies, comparison diets were prepared on the same manufacturing date to ensure that no base ingredient differences existed in the formulations other than the addition of the Eukanuba Dental Defense System™ to one diet. To ensure no product had a mechanical advantage, each dental diet was prepared with the same shape and thickness as the corresponding control.

All testing was conducted in adult animals with normal dentition. Animals were stratified into two groups with diets randomly assigned to each group. Prior to study initiation, all animals received prophylaxis to remove all supra- and subgingival tartar deposits and plaque accumulation. Following prophylaxis, diets were fed amounts calculated to maintain body weight. After 28 days, animals were scored for tartar coverage and underwent prophylaxis followed by exposure to second diet. The utilization of a polyphosphate coating did not impact animal body weight or diet consumption. Separate studies also showed no difference in calcium or phosphorus absorption or blood chemistry. The effect of diet on tartar accumulation in dogs is shown in the ***Table*** below. Results of this study show that the Eukanuba Dental Defense System™ is a viable and effective method for enhancing canine diets to provide dental benefits without compromising kibble size or taste, or affecting the formulation of the food for various lifestages and life styles.

SUMMARY AND CONCLUSIONS

Nutrition can play a key role in dental health. The consistency of a diet, as well as the nutritional components can affect the rate of tartar accumulation. With special care in manufacturing, mineral components can be utilized to provide daily dental benefits without altering kibble size or nutritional value. Research has shown that this approach can provide dramatic reductions in dental tartar accumulation rates. More importantly, this nutritional solution can be incorporated into a broad array of products, including performance foods that are important for dogs competing in field trials and hunt tests so that concerns about high-energy and dental health can be addressed in one product.

Table. *Average dental tartar in dogs fed diets with or without polyphosphate (n=21)*

	Eukanuba® Adult Maintenance dry dog food	Eukanuba® Adult Maintenance dry dog food with Dental Defense System
Average tartar score per tooth	1.60	0.72*
Percentage reduction	—	55%

*Statistically significant at P<.05

REFERENCES

1. Watson A. Diet and periodontal disease in dogs and cats. *Aust Vet J* 1994; 71:313-318.
2. *Taber's Cyclopedic Medical Dictionary,* 16th edition. Philadelphia: F.A. Davis Co., 1989;1364.
3. Eisner ER. Periodontal disease in pets: The Patogenesis of a preventable problem. *Vet Med* 1989; January:97-104.
4. Harvey CE. Periodontal diseas in Dogs: Etiopathogenesis, prevalence, and significance. *Canine Dentistry* 1998; 28:1111-1128.
5. Isogai H, Isogai E, Okamoto H, Shirakawa H, Nakamura F, Matsumoto T, Watanabe T, Miura H, Aoi Y, Kagota W, Takano K.. Epidemiological study on periodontal diseases and some other dental disoders in dogs. J*pn J Vet Sci* 1989; 51:1151-1162.
6. Myers LJ: Sensory and Behavioral Problems of the Sporting and Hunting Dog; Auburn Sports Medicine Seminar, May, 2001, Auburn University.
7. Logan EI, Wiggs RB, Zetner K, Hefferren JJ. Dietary influences on periodondal health. *Small Animal Clinical Nutrition IV*, Mark Morris Institute, 1997; 1-18.
8. DeBowes LJ. The effects of dental disease on systemic disease. *Canine Dentistry* 1998; 28:1057-1062.
9. DuPont GA. Prevention of periodontal disease. *Canine Dentistry* 1998; 28:1129-1145.
10. Roundtable on building your practice with home dental care. *Veterinary Forum* 2000; June:50-57.
11. O'Rourke JT. The relationship of the physical character of the diet to the health of the periodontal tissues. *Am J Orthdontology* 1946; 33:687-700.
12. Burwasser P, Hill TJ. The effect of hard and soft diets on the gingival tissue of dogs. *J Dent Res* 1939; 18:389-393.
13. Egelberg J. Local effect of diet on plaque formation and development of gingivitis in dogs. I. Effect of hard and soft diets. *Odont Rev* 1965; 16:31-41.
14. Harvey CE, Shofer FS, Laster L. Correlation of diet, other chewing activities and periodontal disease in North American client-owned dogs. *J Vet Dent* 1996; 13:101-105.
15. Studer E, Stapley RB. The role of dry foods in maintaining healthy teeth & gums in the cat. *Vet Med* 1973; October:1124-1126.
16. Lage A, Lausen N, Tracy R, Allred E. Effect of chewing rawhide and cereal biscuit on removal of dental calculus in dogs. *JAVMA* 1990; 197:213-219.
17. Duke A. How a chewing device affects calculus build-up in dogs. *Vet Med* 1989; November:1110-1114.
18. Gorrel C. The role of a 'dental hygiene chew' in maintaining periodontal health in dogs. *J Vet Dent* 1996; 13:31-34.
19. Gorrel C, Warrick J, Bierer TL. Effect of a new dental hygiene chew on periodontal health in dogs. *J Vet Dent* 1999; 16:77-81.

Edward Cox, BS

Ed Cox is an alumnus of Wright State University where he received his Bachelor of Science in Chemistry in 1986. He joined Procter & Gamble in 1987 working in the oral care division investigating problems associated with plaque, tartar, stain, tooth sensitivity, and gum health. Mr. Cox has been a regular presenter at the International Association of Dental Research meetings since 1992, and the compilation of his work has resulted in several patents, publications, and television commercial credits. In 1999, he was awarded the American Chemical Society National Technician Award for outstanding achievement. Mr. Cox accepted a position with The Iams Company in 2000 as a research associate and is currently an associate research scientist in the Research and Development Division. As a member of the Strategic Research team, Mr. Cox provides assistance with research efforts in the area of dental care for companion animals.

Breeding Management for Success

Russ L. Kelley, MS

DEVELOPING BREEDING PROGRAMS

Successful breeding programs do not just simply happen, they are developed, often reflecting years of effort. To be successful, one of the first things that a breeder must ask and answer is "What am I trying to accomplish"? This question is just as important to the breeder that owns one dog as it is to the breeder who owns 50. But how does one effectively answer this question? First, create a mental picture of what you feel would be the perfect dog. Once you have this image, list out the traits that make your perfect dog perfect. This should answer the question "what am I trying to accomplish." The next step would be to establish a set of well-defined goals for the breeding program.

Unfortunately, many breeders simply rely on luck. Goals will serve as a reference point allowing the breeder to evaluate their efforts. These goals should be well defined and concise, as poorly defined goals will not positively contribute to any breeding program. If so, one could simply breed any bitch to any dog. Although setting goals for one's breeding program can be a daunting task, the task can often be simplified by first critically evaluating the bitch. A simple, but effective, point to start is by asking: *Knowing what I know now, would I still buy this bitch?*

This is probably one of the most difficult questions for the breeder to answer because the vast majority of bitches are acquired as puppies or young adults, thus there is an emotional bond after years of companionship. It is imperative that the evaluation be based on fact, however, not emotion. If the answer is no, simply do not breed her. But if the answer is yes, further analysis is warranted before the final decision to breed is reached.

What are the strengths and weakness of this bitch? By listing the bitch's traits into categories, the breeder will not only be able to evaluate whether the bitch is worthy of being bred, but also what type of dog she should be bred to. But what traits are important? There are no hard rules to answer this question. The breeder must, as thoroughly as possible, list what traits they are trying to acquire (or maintain) and which traits they are trying to avoid and then evaluate how their bitch measures against those standards. Also, classify the traits as primary and secondary. Primary traits are ones that the breeder deems essential. Secondary traits are traits that are nice to have, but not necessary.

Primary Traits

Concentrate first on the primary traits, which should include traits that are highly heritable, such as conformation. While conformation flaws do not mean that an animal will not perform well in the field; flaws such as hip dysplasia can certainly place limits on an animal's ability and longevity. Does the bitch come for a pedigree with reproductive problems, such as poor milking ability? Other primary traits that could be important, depending on breed, could include nose strength, hunting range, or drive. A good rule of thumb on trait heritability is that structural traits (conformation) are more heritable than functional traits (reproductive), which are more heritable than behavioral traits (pointing style). Because of this, a breeder should be more critical of traits with high heritability indices, such as conformation.

Secondary Traits

Secondary traits often have little impact on performance. Traits such as coat color or coat markings would be examples of secondary traits. However, the breeder must be careful not to completely dismiss these traits. Remember the mental picture of your perfect dog, it is often these secondary traits that provide the final touches to the animals the breeder is trying to create.

Once a breeder has listed out the strengths and weaknesses of a bitch and still feels that she should be bred, the next step would be to identify a group of potential sires. While this decision is also difficult, the breeder should be half way there. Use the list of strengths and weaknesses for the bitch to identify what traits need to be strengthened. If the bitch is slightly weak in conformation, identify only potential sires with strong conformation. Basically, try to offset any weakness in the bitch by selecting a sire that is strong in that trait. In turn, the bitch's strengths should offset any weaknesses of the sire. One of the biggest errors a breeder can make is to select breeding stock based on convenience. Breeding your bitch to the dog next door will get you puppies, but probably not the type of puppies you want. Remember that as a breeder, you should be striving to produce puppies that improve the breed in both form and function.

MANAGING THE BROOD BITCH

Pre-Breeding

Proper management of the brood bitch does not begin at breeding. Just as one must prepare a dog for competitive or hunting activity, one should also prepare the bitch for an upcoming breeding. Before being bred, the breeder should take every precaution to ensure that the bitch is in ideal health. A visit to your veterinarian for a physical examination is a worthwhile step. Prior to breeding, every bitch should be current on all vaccinations and free from infections and parasites. It is also a good idea to request documentation of health status on the sire, regardless of source. While relatively uncommon today, *Brucella canis* remains a serious threat and can destroy years of efforts.

In addition, the breeder should ensure that the bitch is in good physical condition. Like all dogs, the breeding bitch should receive daily exercise and be maintained on a diet that matches energy needs relative to energy output. The breeder should strive to condition the bitch to possess evident muscle tone while also possessing a slight degree of body fat. This type of body condition will help promote a healthy endocrine system that will be critical for the success of the reproductive process.

When to Breed

For decades, dog breeders have searched for a method to accurately predict the correct time to mate. Vulvular swelling, pro-estral bleeding, willingness to stand, flagging of the tail, swabs of the vaginal wall, and arbitrary day timing have all been utilized. However, none of these methods are accurate enough to allow certainty in timing a mating. Traditional timed breeding is still widely utilized and often achieves 90% pregnancy rates. The most common approach to timed matings is to breed the bitch on the second and fourth day after she is willing to accept the male. However, current knowledge about canine endocrinology allows for more accurate estimates for the best mating time.

The reproductive cycle of the bitch is composed of four phases: proestrus, estrus, metrus (diestrus), and anestrus. Each phase can be distinguished, although not always easily, via physical or endocrine events. One of the endocrine events, the rise in circulating progesterone levels, can be utilized to accurately predict ovulation. Bitches may ovulate on the third day of spotting blood or as late as 21 days later. The fact that fresh dog semen can live and remain viable in the uterus for around 5 days is nature's way of ensuring that most bitches get pregnant. However, unlike fresh semen, fresh chilled extended stored semen only remains viable for around 3 days and frozen semen for around 1 day. Thus if artificial insemination (AI) is going to be used, breeders should utilize a more sophisticated system than the traditional timed method to ensure success.

Ideally, the kennel veterinarian is involved in determining the correct mating day. Testing of the bitch should begin on day 5 of proestrus (bleeding) or when the veterinarian determines the tests are appropriate. Blood samples should be collected every two to three days until hormone changes signifying ovulation are detected. Once the first increase in progesterone is detected, mating should be scheduled four to six days later.[1] If AI is being considered, the testing should continue until progesterone levels have reached 5 ng/ml which would indicate that ovulation has occurred. The bitch should be bred 2–3 days after ovulation, which would correspond to the fertile period.

Breeding

For any dog breeder, there are two basic choices available for breeding a bitch: a natural mating or artificial insemination. The physical mating of dogs can be simple or frustrating. Male dogs vary considerably in their willingness to mate and some may require manual help or at least psychological encouragement. A ready, easy breeding male is a valuable asset.

During the physical mating, the female is often restrained (muzzle and leash) as a bite or escape effort can injure the male. However, bitches that are aggressive or overly reluctant to breed should be evaluated to ensure the timeliness of the mating (see section "When to Breed"). Many of these resistant bitches are in late proestrus as opposed to true estrus. Remember that most males are always willing to breed before the bitch is receptive, thus they are not good indicators. Ideally, copulation will result in a true tie with dog and bitch assuming the butt-to-butt position for several minutes. During this time, the male continues to ejaculate, depositing the semen near, but not into, the cervical opening of the female. Without this prolonged ejaculation, the chance of successful fertilization is decreased.

While natural matings are still considered the most effective method by most reproductive experts, AI does offer some distinct advantages and is growing in popularity among dog breeders. This is in part due to advancements in AI techniques, but probably more so due to the demand that the breeders place on themselves to breed their bitches to the top males, regardless of the distance between kennels. In addition, many stud dog owners prefer to AI, even if they own the bitch, to decrease the chance of injury to their valuable dog.

The AI process, while not difficult, will not be discussed in depth in this document since it is recommended that anyone interested in learning this technique seek professional training or at least supervision by a person experienced in the art of male collection and bitch insemination. We make this recommendation due to the fact that injuries resulting from the inexperienced hand can permanently disable a valuable animal.

Artificial insemination can be performed using either fresh, fresh chilled extended, or frozen semen. Fresh semen AI is merely the collection of semen from the male followed by vaginal insemination of the bitch. The use of fresh semen AI is often used and preferred by owners of extremely valuable males. As mentioned earlier, this reduces the chance of the male being injured during copulation. Although not necessary, it is recommended that the semen be evaluated to ensure that the sperm is mobile. One drawback to fresh semen AI, like natural matings, is it requires that the dog and bitch be housed at a common site or at least in very close proximity. In contrast, fresh chilled extended semen is collected from the dog, processed, and stored refrigerated for several days until needed. The major advantage of fresh chilled extended semen is that it allows semen to be shipped from practically anywhere in the world to the bitch. This allows breeders more economical access to the highest quality males possessing the traits they seek. Since it is much less expensive to ship a semen vial in a cooler than the bitch or stud, the use of fresh chilled extended semen has increased dramatically over the past few years.

To date, the majority of AI matings involving frozen semen are done because the dog is no longer fertile or in most cases alive. If frozen semen will be used, the breeder is strongly urged to work with their veterinarian or a veterinarian specializing in reproduction. This recommendation is based on 1) the reduced viability time of frozen sperm and 2) cost. Semen worthy of cryogenic preservation is often very expensive, in some cases several thousand dollars per dose. In matings utilizing extremely expensive semen, the breeder may also wish to consider working with a reproductive specialist to employ the use of transcervical insemination or intrauterine surgical semen deposition. Although more expensive, both generally offer a greater chance of pregnancy than would a simple vaginal insemination.

NUTRITIONAL SUPPORT DURING PREGNANCY AND LACTATION

Nutrition is one of the most critical components related to an animal's performance in the field. The same is true for the reproducing bitch. In fact, outside an animal's genetics, nutrition is probably the single most important component to a successful breeding. Unfortunately, many breeders fail to appreciate the nutritional demands placed on the bitch

during pregnancy and lactation. Much as an umbrella protects us during a rainstorm, optimal nutrition will help protect the bitch and her progeny from the various metabolic and environmental stresses that will occur during the pregnancy and lactation periods.

During the reproductive process, a bitch's diet must support three areas: 1) her body maintenance, 2) the growth of her reproductive tissues, and 3) the growth and development of her offspring ***(Figure 1).*** However, the requirement and nutrient priority are not equal between the areas. Once the bitch has undergone maternal recognition of pregnancy, the developing offspring will have the highest nutrient priority followed by her reproductive tissues, with her body's maintenance having the lowest priority. A key component to remember is that unlike the bitch, the developing offspring have two sources of nutrients: the bitch's diet and the bitch's body ***(Figure 1).***

Should the bitch's diet fail to meet the required nutrient levels, the bitch will respond by sacrificing her body's maintenance and mobilize nutrients from her body's fat, muscle, and skeletal tissue for the developing offspring and reproductive tissues. In extreme cases, her only solution may be to reduce the demand by decreasing the number of offspring or aborting the pregnancy all together. To what extent the bitch is able to offset these nutrient shortfalls remains unclear. However, since deficiencies in maternal nutrition in other species have now been associated with adult disorders in progeny,[2] it is critical that the breeder make all attempts to supply optimal maternal nutrition.

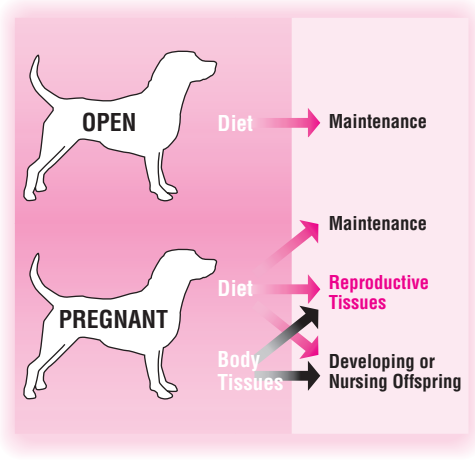

Figure 1. *Utilization of dietary nutrients by the brood bitch.*

Campbell and Phillips[3] and Ontko and Phillips[4] provided some of the earliest insight into the specialized nutritional requirements for the reproducing bitch. In both studies, diets known to be sufficient for canine growth and maintenance were found to be inadequate for reproduction. However, these studies were conducted almost 50 years ago and it is doubtful that any modern growth formula would not be sufficient for reproduction. But, sufficiency should not be the target. Sufficiency does not equate to optimal nutrition. Sufficiency simply means the bitch is able to complete the reproductive process. Collins[5] concluded that the stress associated with reproduction would manifest even the smallest of nutrient inadequacies in diets assumed to be complete. These dietary inadequacies may not be severe enough to inhibit the bitch from reproducing, although most likely they will prevent her from performing at her genetic potential.

Essential and Non-essential Nutrients

Nutrient supply is routinely described relative to gross composition with diets; for example, X% protein, Y% fat, and so forth. But just as the old saying "All diets are not created equal" is true, the same can be said of dietary nutrients during pregnancy and lactation. In a broad sense, dietary nutrients are defined as essential and non-essential. Essential nutrients cannot be adequately produced by an animal's body to meet the animal's requirement, thus must be obtained through the diet. Essential nutrients would include the essential amino acids, essential fatty acids, as well as various minerals and vitamins. Conversely, non-essential nutrients can be supplied via the diet or produced by the body should dietary sources fail to supply sufficient quantities.

This concept does not hold true for the developing offspring. Puppies (embryonic, fetal or nursing) are dependent upon the bitch to supply them with all nutrients. Because many of the metabolic pathways to produce non-essential nutrients are not functional until late neonatal life, all nutrients are in a sense "essential". However, this is not to imply that one should simply switch to a diet that contains the highest available nutrient content (protein or energy or both) or use various dietary supplements to enhance a food. Excess-nutrition can be as

detrimental as nutrient deficiencies. Excess dietary energy can often contribute to increase pup morbidity and excessive maternal weight gain, which dramatically increases the chance of dystocia during parturition.

The use of dietary supplements can supply excessive amounts of nutrients such as minerals, thus altering the balanced dietary matrix of the diet. The key to optimal nutrition is supplying a food that has a balanced nutrient profile at levels that meet the animal's needs. As Mosier[6] stated in 1977, "only by feeding well managed balanced diets can the health of an individual be maximized". Thus components within the dietary matrix that should be considered are not only the level of protein, fat, carbohydrate, vitamins and minerals, but also the type of protein and fat and the ratio of nutrients such as protein to fat.

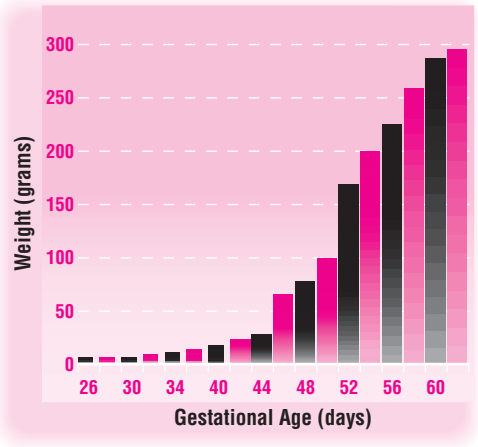

Figure 2. *Fetal puppy body weight (grams) plotted throughout pregnancy.*

WHAT TO FEED?

Owners or handlers of competitive or sporting dogs generally have higher performance expectations than the average dog owner, thus this question is often a little easier to answer. They have experience in what performance formula has provided them with positive results as well as those that have not. For the breeding bitch, the same logic must be applied, only to a higher extent. Most competitive or sporting dogs will require around twice the nutrition during the active season as they do in the off-season. However, the nutritional requirements for the pregnant or lactating bitch are not constant. Her requirement levels are influenced by the stage of the reproductive cycle as well as her litter size and genetic ability (milk). During early and mid gestation (first 5 weeks), the energy requirements of the bitch are approximately equal to maintenance. However, as fetal growth accelerates during late gestation ***(Figure 2),*** the bitch's energy requirements also grow ***(Figure 3),*** with additional increases occurring during lactation. While not common, some bitches may require up to 5 times normal requirements during peak lactation (days 21–34 post-whelping).

Again, you may ask, "what should I feed?" First and foremost, select a commercially available premium food from a reputable company that is formulated with animal based protein sources and recommended for gestation and lactation. While there are many "homemade" diet recipes circulating, it is extremely difficult to achieve a complete and balanced diet using these recipes. These diets can often be deficient in vitamins, minerals, or other nutrients and are undefined with regard to amino acid and fatty acid levels. They may also vary over time due to an inconsistent ingredient supply. Commercial formulas offer distinct advantages by allowing the breeder to feed a product of known nutrient content and type proven to support the reproductive process.

Approximately two weeks prior to breeding, the bitch should be transitioned (if necessary) from her maintenance diet to a diet comprised of approximately 30% highly digestible animal-based protein and 20% lipids. The lipid (fat) portion of the diet should be balanced for fatty acid content to supply an omega-6 to omega-3 fatty acid ratio in the range of 5:1 to 10:1.

Findings from a recent study conducted by The Iams Company comparing three diets demonstrated positive benefits of feeding this dietary matrix (Eukanuba® Premium Performance Formula).[7] When fed throughout the reproductive cycle, this diet resulted in fewer misconceptions, a reduced number of stillbirths and more consistent-sized litters from breeding to breeding ***(Figure 4).***[7] The exact amount of food required will vary depending on breed and metabolic rate, however, the level of intake should be closely monitored to target a caloric intake similar to maintenance levels, thus avoiding over-feeding the bitch.

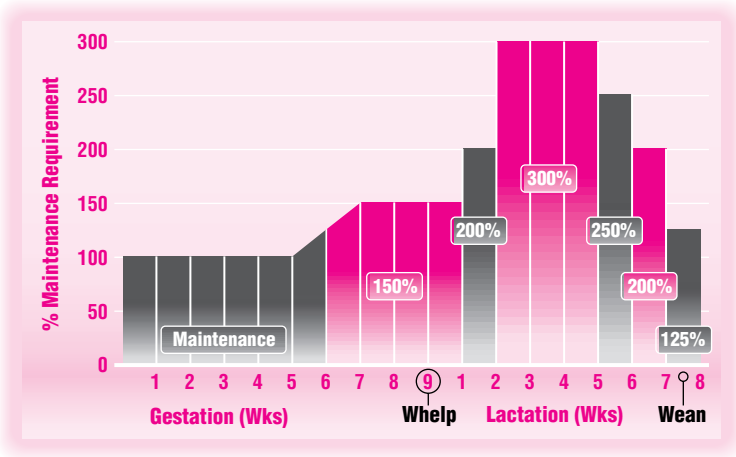

Figure 3. *Estimated energy requirements of the pregnant and lactating bitch relative to maintenance. Adapted from Lepine AJ. Feeding managemnet of the reproductive cycle, in Proceedings. Canine Reproductive Health Symposium at the 1997 North American Veterinary Conference; 27-29.*

As stated earlier, during the first 5 weeks of pregnancy, the breeder should continue to feed the bitch a 30% protein, 20% fat diet at maintenance levels (energy basis). It is possible that you may observe a change in the bitch's appetite at approximately 3 weeks post-breeding, first decreasing followed by a dramatic increase. But this may not indicate that you are overfeeding or underfeeding the bitch. This period of pregnancy parallels maternal recognition of pregnancy and embryonic implantation that may trigger these appetite changes. It is very important that the bitch be maintained on her normal routine during this period to prevent any undue stress, which could be detrimental to the pregnancy.

At approximately 5 weeks post-breeding, the food intake of the bitch should be increased slightly each day to achieve a 50% increase in energy by the end of week 6 ***(Figure 3)***.[8] For example, if the bitch is consuming 1,000 calories/day for maintenance, by the end of week 6, she should be consuming approximately 1,500 calories/day. One can generally obtain this information from the product manufacturer. It will be necessary to closely monitor the bitch for weight gain during the later portion of gestation to ensure that she is gaining sufficient weight.

It is impossible to give an exact percentage of weight that a bitch should gain since the increase will vary greatly from breed to breed even within similar adult sizes. For instance, one would expect a Labrador Retriever to gain more weight (as a percentage) than a English Setter since they typically give birth to larger litters. However, a good rule of thumb would be to target a 25% weight gain in the bitch by the end of week 8 (day 56) post-breeding.

Dietary Supplements

The use of dietary supplements for the gestating bitch has been the topic of many debates. Numerous publications have hinted at the benefits of nutrient supplementation.[3,4,9] Some of the most commonly mentioned nutrients include protein, calcium, and vitamins. In practice, the only reason to utilize dietary supplements is when the diet fails to supply the needed amount of a given nutrient. However, the theory of supplementation is often much easier than putting it into practice. The majority of currently available commercial foods are formulated to provide a balanced supply of nutrients, with "balanced" being the key word.

A critical point to remember is that nothing can be added to or taken away from a diet without affecting the overall nutrient profile. One should also remember that few supplements are pure sources of a given nutrient. For

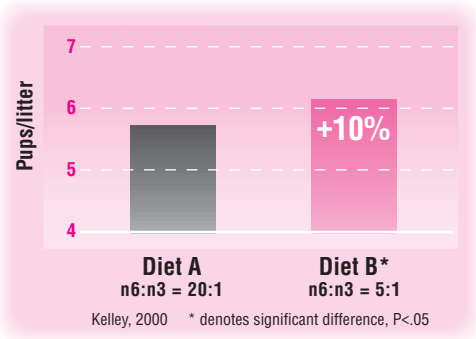

Figure 4. *Effect of dietary fatty acids on litter size in Beagles.*

example, cottage cheese (for calcium) and liver (for protein) are two commonly used diet supplements for the breeding bitch. However, since neither of these foods are composed of a single nutrient, the net result supplies more than just the desired nutrient. For example, both cottage cheese and liver add large quantities of phosphorus. In fact, cottage cheese adds more phosphorus than calcium, the targeted nutrient ***(Table).*** Thus if incorporated into the diet, the calcium to phosphorus ratio of the diet will be altered. While the intention is good, it is important not to confuse an increase in the level of nutrition required with a need to change the diet profile.

The bitch does require that nutrient intake be increased during the latter phase of pregnancy and lactation, however, the increase does not mean that the diet profile should be altered. It is critical to remember that during these periods, the bitch will be consuming a greater volume of food, which will increase her nutrient intake but maintain dietary balance with regard to the formulation ***(Table).***

CONCLUSIONS

Feeding your bitch does not have to be complicated. While the science associated with nutrition and reproduction may require years to understand, the actual practice of providing nutrition can be summarized fairly simply, *feed the appropriate amount of a diet that meets the animal's needs*. While this practice still requires the breeder to make evaluations as to the exact diet that will be fed, it does eliminate questions such as to what mix of products and/or supplements must be utilized.

Based on our efforts in the area of canine reproduction, the greatest success has been achieved feeding a diet, such as Eukanuba® Premium Performance Formula, consisting of approximately 30% protein (animal-source based) and 20% fat with an omega-6:3 ratio of 5:1 to 10:1. The benefits of feeding this formula have included increased conception rate and live births and more consistent maternal productivity.

While nutrition is only one component of bitch management, it is one of the most (if not the most) important. Thus by providing the proper nutrition, the breeder has taken a great step forward in achieving a successful breeding program.

REFERENCES

1. Hutchison R. Maximizing neonatal survival, in *Proceedings*. Canine Reproduction for Breeders, New York, 2001; 18-21.
2. Godfrey KM, Barker DJ. Fetal nutrition and adult disease. *Am J Clin Nutr* 2000; 71(5 Suppl):1344S-1352S.
3. Campbell JE, Phillips PH. Reproduction studies in dogs. *J Nutr* 1952; 47: 621-629.
4. Ontko JA, Phillips PH. Reproduction and lactation studies with bitches fed semipurified diets. *J Nutr* 1957; 65: 211-218.
5. Collins DR. The reproducing bitch. In: *The Collins Guide to Dog Nutrition*. 6th ed. New York:: Howell Book House, 1987; 231-236.
6. Mosier JE. Nutritional recommendations for gestation and lactation in the dog. *Vet Clin N Am* 1977; 7(4):683-692.
7. Kelley RL. Canine Reproduction: What should we expect? In: Reinhart GA, Carey DP, eds. *Recent Advances in Canine and Feline Nutrition, Volume III: 2000 Iams Nutrition Symposium Proceedings*. Wilmington, OH: Orange Frazer Press, 2000; 225-242.
8. Lepine AJ. Feeding management of the reproductive cycle, in *Proceedings*. Canine Reproductive Health; Proceeding from The North American Veterinary Conference. 1997: 27-29.
9. Moser E. Feeding to optimize canine reproduction efficiency. *Prob Vet Med* 1992; 4:545-550.

For Author Profile, see page 16.

Table. *Effect of dietary supplements on the nutrient balance of a commercial diet**

		ALTERED NUTRIENT LEVEL BY ADDITION OF		
Nutrient	**Amount of Nutrient Provided By Feeding 300 grams of Dry Diet***	**½ cup Cottage Cheese**	**3 oz. Beef Liver**	**100 g Extra Dry Diet**
Protein (g)	93	106	115	124
Fat (g)	63	67.5	67	84
Calcium (mg)	3500	3563	3509	4700
Phosphorus (mg)	2900	3080	3305	3850
Ca:P (ratio)	1.2:1	1.15:1	1.05:1	1.2:1

*Based on the average analysis of Eukanuba® Premium Performance, guaranteed to contain 30% protein, 20% fat, and 4452 kcal metabolizable energy (ME).

Conditioning the Field Trial Dog

Terry Terlep, DVM

INTRODUCTION

Because of my love for bird dogs and field trials, several years ago I began trying to define the differences between the winning dogs and the losing dogs. Certainly there are many, many factors involved but in most cases the difference was a matter of conditioning—which dog could run and hunt without slowing or quitting. I soon learned that tired dogs stop thinking and stop hunting.

There are no secrets about conditioning dogs to compete. It is simply a matter of doing the usual in a manner unusually well. If we do the little things right, the big things will fall into place. Maximizing your dog's potential is the goal of this program—being better prepared and conditioned to win. Your visions and dreams of winning championships can become reality if your dog is properly prepared and conditioned to win.

WINNING FACTORS

There are seven winning factors that determine the success of the field trial or hunt test dog in competition or on an afternoon hunt.

1. **Genetics.** We breed the best to the best and hope for the best. Dogs are what they are in large part because of their genetic inheritance. Man can nurture, properly train and condition dogs, but much of what they develop into is controlled by their genetic make-up.

2. **Nutrition.** It has often been said we are what we eat and the same holds true for our dogs. Athletes can only perform to the best of their ability if they are given the nutrition they require for maximum performance.

3. **Conditioning.** Proper conditioning prepares your dog for optimum performance. Canine athletes cannot be expected to successfully compete and win unless they have been properly conditioned to win.

4. **Training.** Every great dog had a great trainer and the trainer deserves much recognition.

5. **Health.** Athletes must stay sound and healthy to be successful. By providing proper vaccinations and parasite prevention we are able to prevent the majority of the serious diseases and conditions in the canine athlete.

6. **Desire.** Some dogs exhibit the inborn desire to be successful—the "will to win". This may trace back to the breeding, but dogs in the same litter often show different levels of desire.

7. **Luck of the Draw.** In field trial competition, the luck of the draw is always a factor. The course you run on, the time of day, and the weather all play a role in winning.

CONDITIONING THE CANINE ATHLETE

Conditioning includes the body (physical conditioning) and the mind (psychological or mental conditioning). We must address both areas. The plan is simple: get the dog fit enough to compete at a high level and keep them happy enough to want to compete at that level.

Physical conditioning involves three body systems.

1. **Musculoskeletal.** Muscles, bones, tendons and ligaments; this system is the hardest to condition and requires the most time
2. **Cardiovascular.** Heart and blood vessels
3. **Pulmonary.** Lungs and airways

The cardiovascular and pulmonary systems are in constant use and therefore very easy to condition. The three systems can be properly conditioned simultaneously, using the same techniques.

Warming up

It is a common practice in all human and animal (horse) athletes that some amount of time be devoted to warming up, prior to an athletic event. As the muscles are stretched they are "warmed up" and blood flow is increased to the muscles, joints, tendons, and ligaments. In my experience, this warming up reduces the potential for muscle or ligament fiber tearing and is the best way to prevent injuries to these structures. Warming up the canine athlete for 5 to 10 minutes will not fatigue the dog and will minimize glycogen depletion and lactic acid build-up. Human and equine athletes do not start competition without proper warming up exercise; it is also beneficial to warm up bird dogs, Retrievers, and field trial Beagles prior to competition.

Cooling Down

After athletes compete there is a specific routine for cooling down. Horses are brushed and hot-walked until dry; human track runners "walk out" after they catch their breath. For dogs, this cooling down period is important for muscle recovery and lactic acid dissipation as it helps to flush out metabolites produced by exertion, thereby preventing delayed onset muscle soreness. When the brace or series is over, if we were to allow the dog to catch his breath (blow out) and road slowly for 5 to 10 minutes, we would prevent much of the soreness that develops after strenuous exercise.

CONDITIONING TECHNIQUES

The conditioning system that I use is called the "cross training concept", which combines endurance training with strength training. *Endurance training* or marathon training involves running long distances. To increase endurance the dog runs long distances at submaximal intensity. *Strength training* or power training includes roading, pulling, and uphill work. To increase the dog's strength, workouts are of short duration with maximum intensity. It is important to remember that our dogs must be strong and sound before we work them for long durations.

The length of time spent on daily conditioning depends on the intensity, duration, frequency, and method of training. Training methods most often employed to condition bird dogs include running, roading, and swimming. Running exercise can be accomplished by various means, such as running free while hunting, running and pulling weights such as cables or chains, running beside a 4-wheeler, running on a merry-go-round-type dog walker, and running on a treadmill. The use of the treadmill has become very popular, especially among amateur field trialers since many households have treadmills and the dogs can be worked in the evening after a day of work. Many treadmills can be elevated up to 20 degrees, which increases the work load and is considered uphill work. It is very important that the dog be supervised constantly when working on a treadmill so it can be stopped if need be for any reason. Roading, which by definition is resistance training, requires the athlete to lean into harness and pull vigorously. Dogs are most often roaded from ATV's or horses at a rate of 8–12 mph for various lengths of time. Swimming can be used to condition canine athletes; especially those individuals, which are sore from running on hard ground and those older dogs that have some degree of traumatic joint disease (arthritis).

Research conducted at Auburn University by Drs. Altom, Tyler, and Cummins demonstrated that non-conditioned dogs had a lower olfactory activity (ability to smell) following exercise when compared to the conditioned dog. After one hour of treadmill exercise at 11° slope and 7 mph speed, they demonstrated that the non-conditioned dog had a 69% decrease in their ability to smell. In comparison, conditioned dogs had a 6.6% increase in their ability to

smell. In my experience, tired, non-conditioned dogs quit hunting as they lose their ability to smell.

Uphill Work

It stands to reason that muscle fatigue in the athletic dog impedes performance. The first muscles to weaken are in the back. They are the longissimus muscles that run from the neck to the pelvis. The action of these muscles is the raising of the front of the body from the pelvis and the sudden raising of the back portion of the body, which is initiated by the rear legs. The primary cause of soreness in the canine athlete is fatigue of the longissimus muscles. Uphill running is used to condition this muscle group.

PSYCHOLOGICAL CONDITIONING

I have observed many times what I call a "burned-out" field trial dog. These dogs run, but do not hunt, or they may run off to escape the pressure of competition or training. The dog's gait and tail indicate unhappiness or soreness. These dogs are apathetic, bored, and uninterested in field trailing or hunting. They have lost their excitement to work either from stress or pain. In some cases, these dogs exhibit nervous tremors or symptoms at the breakaway indicating their mental state. Our canine athletes become physically sore and/or emotionally or mentally fatigued.

A physically sore dog needs a "vacation" from the circuit to heal and mend. If we give the dog the time he needs to recuperate now, he will repay us many times in the future. Conversely, if we do not permit him the time to recuperate he may not be seen in the field next season. Dogs become emotionally and mentally fatigued due to the rigors of a long campaign on the major circuit or the long hunting season. The dogs have been up and down the road for a long time, living in dog boxes and on stake-out chains at trials. Pressure from owners require that trainers continue to campaign dogs throughout the season and the financial needs of the trainers require that a dog compete to win throughout the season.

How do we treat the burned-out bird dog? There are no pharmaceuticals available to help so we must rely on personal attention and "TLC" from humans. Frequent petting or brushing, leash walking, playing fetch, feeding cookies and treats are all beneficial activities to establishing the human-animal bond and will help to perk up the down dog. The simple act of allowing the dog to ride in the front of the truck between trials or bringing him into the house for added attention will help. Perhaps one of the best methods to rejuvenate a burned-out dog is to take him hunting and kill birds over the dog's points, or let him spend a day in a real duck blind retrieving wild mallards. If large exercise pens are available the green grass, sunshine, and freedom does wonders for dogs that have lost their desire to excel.

SPECIFIC CONDITIONS RELATED TO CONDITIONING

Hypoglycemia

Often called "sugar fits", hunting dog hypoglycemia or exertional hypoglycemia occurs when the blood sugar level falls below 50 mg/dl (normal values are 70–110 mg/dl). Signs of this condition may include trembling, anxiety, nervousness, and ataxia (wobbliness) and could progress to collapse, seizures, and coma. The signs most often seen while working are ataxia and collapse. An immediate treatment using an oral sources of sugar such as Karo® Syrup (15 gm carbohydrate/tablespoon), honey, a cola drink (41 gm of carbohydrate/12 oz. can), table sugar, pure fruit juice, or a sport drink (84 gm carbohydrate/12 oz.) is necessary.

It is important to administer products slowly and carefully, as the dog may not be able to swallow properly. Most cases of hypoglycemia occur early in the season when the dogs are not fully conditioned and when the weather is hot. Field treatment is a must and should be done at the first sign of being wobbly. Often these dogs will be overheated and should be cooled down prior to being put back into the box or crate.

Exertional Myopathy

Exertional myopathy, also called "tying up", Azoturia, Monday Morning Sickness, or exertional rhabdomyolysis is a condition that leads to muscle damage. It often occurs early in the season before the dogs are fit and conditioned. Other factors involved may include the frequency of the workouts (too much too soon),

heat stress or over-excitement in young dogs. The signs include muscle swelling and pain, most notably over the back and hind leg muscles. Other signs seen would include rear leg stiffness, severe distress, and in serious cases, collapse. When this condition is suspected it becomes extremely important to seek veterinary attention quickly before it progresses to a life threatening state.

Hyperthermia

Also called heatstroke or heat prostration, this condition occurs when the dog's body temperature exceeds the body's ability to cool itself. This condition causes thermal damage to many tissues of the body and can lead to life threatening organ dysfunction and failure. High temperatures and high humidity while running or roading account for the majority of heatstroke in trial and hunting dogs. Lack of acclimatization to the area also plays an important role in the development of this life-threatening condition. Virtually every system of the body is affected by heat stroke. Signs include hyperventilation, altered mental states, diarrhea and vomiting, bleeding from any body opening, weakness, and eventual collapse.

Treatment of hyperthermia in the field requires aggressive measures early. The core body temperature must be lowered to prevent permanent damage to tissues by the liberal use of water all over the outside of the body. Ice on the head and/or belly can be very effective along with getting the dog into an air-conditioned vehicle to cool down. ***Do not*** immerse the dog in ice water or ice. If the condition is extreme or collapse occurs, seek veterinary attention immediately. Secondary complications can be a life or death crises.

SUMMARY

The goal of the conditioning program is to enhance the lives and well-being of our dogs and to maximize their ability to compete in field trials. Proper conditioning serves to strengthen and enhance the capabilities of our canine athletes. We look forward to the future as new concepts and technology derived from research will enable us to better prepare and condition our dogs for competition.

Terry Terlep, DVM

Dr. Terlep is a 1970 graduate of Purdue University veterinary school. He has practiced in Fort Myers, Florida for the past 28 years. His affiliation with field trials spans more than two decades. He has judged from the Deep South to the Canadian prairies. Dr. Terlep is past president of the American Canine Sports Medicine Association, and is a current board member of the Auburn University Sports Medicine Program Advisory Panel. He has served as speaker for many top dog awards programs over the past two decades. Included in the many contenders he has campaigned on the major circuit are Tekos Mountain June, Pike Creek Mike, 1999 National Champion Whippoorwill Wild Card, and Quick Cash.

Innovative Research in Dog and Cat Nutrition®

Makers of Eukanuba® and Iams®
premium dog and cat foods, and
veterinary exclusive canine and
feline Eukanuba Veterinary Diets®

7250 Poe Avenue
Dayton, OH 45414 USA
1-800-535-VETS (8387)
www.iams.com