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Farm and Home Research: 57-4

Lance Nixon

Marianne Stein

Utilizing and developing our resources to enhance quality of life

Farm & Home RESEARCH

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South Dakota State University · College of A ces · Agricultural Experiment Station

CONTENTS

This is the final issue of *Farm & Home Research* from the South Dakota Agricultural Experiment Station. The staff thanks readers for their support and invites them to watch for a new and expanded magazine reporting the research, teaching, and Extension activities of the College of Agriculture & Biological Sciences.

On the cover:

Who wouldn't have traded places with Ashly Steinke, SDSU Wildlife and Fisheries Sciences graduate student—spending two field seasons in the Black Hills, meeting hospitable landowners, visiting with out-of-state hunters, riding horseback through the Hills, and trapping and following the radio signals of Merriam's turkeys to discover their mortality during the spring gobbler season. Hunters in the Hills have increased by about 97% since 2000; 60% of them are nonresidents looking for a trophy tom. Will the good hunting last?

Farm & Home RESEARCH

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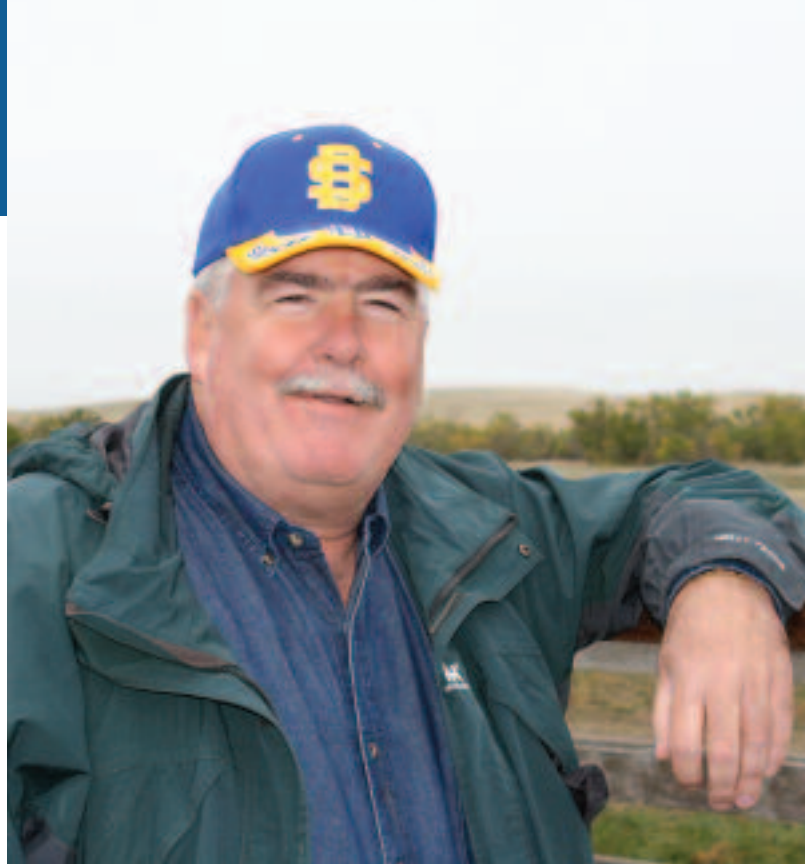
DIRECTOR'S COMMENTS

BY JOHN D. KIRBY
Director, South Dakota Agricultural Experiment Station



John Kirby

21ST CENTURY AGRICULTURE: Food, Feed, Fiber, and Energy

As you look at the articles contained in this edition of Farm & Home Research you will see a broad range of work that reflects the diversity of science and approaches in South Dakota's Agricultural Experiment Station. One theme that runs throughout is that there are tremendous challenges and opportunities arising in contemporary agriculture. These issues range from the stewardship of our natural resources and the challenges of drought to the continued expansion of the biofuels industries.

Station scientists and their colleagues in industry and other colleges and universities are addressing these and a myriad of other issues pertinent to South Dakota and the nation. These include the multi-institution effort to sort out the complexities of dormancy and its control in grapes led by Dr. Anne Fennel and colleagues. This large project is the result of years of work and the recognition by the National Science Foundation that the collaborative team assembled by Dr. Fennel was among the finest in the world—a true testament to the high quality of programs emerging from long-term investments in agricultural biotechnology at SDSU. Another example of breadth is the prairie pothole project directed by Professor Carter Johnson and funded by the Environmental Protection Agency, a long-term assessment of water issues in South Dakota.

One big issue, indeed the elephant in the room, that seems to enter every conversation is the growth of the agricultural biofuels, primarily ethanol and biodiesel, industry in South Dakota. The rapid expansion of this relatively new industry has stimulated a good deal of hyperbole, both pro and con, nationwide. SDSU scientists are working on numerous aspects of this emerging field—from discovery of new processes in the conversion of plant material from corn stubble and switchgrass to ethanol and improved utilization of co-products for livestock feed and other useful products. In this regard, our collaborations with the USDA-ARS lab in Brookings are paying tremendous dividends and extending the range of high quality work we can do in this area.

As the efficient conversion of cellulose to fuel becomes a reality a new set of issues will arise for South Dakota's farmers and ranchers. These range from the continued availability of livestock feedstuffs to the effects of long-term harvest of corn stalks and wheat straw on soil quality. For example, SDSU Experiment Station scientists are working to evaluate the value of organic material returned to the soil or harvested for cellulosic ethanol production. The multidisciplinary approach includes engineers, soil scientists, economists, agronomists, and others and has as its goals the understanding of this rapidly approaching issue and the establishment of effective production guidelines that will allow South Dakota producers to make informed decisions to optimize farm income while maintaining their soil for future generations.

We look forward to the challenges of continuing to serve all South Dakotans as the face of agriculture continues to change through the 21st century.◆

GRAPES IN WINTER, WETLANDS IN DROUGHT, AND A RESEARCH PARK

The first research park in the state, South Dakota State University's new Innovation Campus, will include major emphases on agricultural research. At groundbreaking ceremonies in Fall 2006, Gov. Mike Rounds pledged almost $3 million over the next 3 years for the park's Seed Technology Building to establish the 2010 Research Center for Drought Tolerance Biotechnology.

With South Dakotans still suffering from drought in parts of the state, Rounds said the new research center will foster development of new commercial varieties in corn, wheat, oilseeds and possibly even short-season soybeans.

Director John Kirby of the SDSU Agricultural Experiment Station said the center will focus on applied crop genomics with an emphasis on abiotic stress—factors such as drought, temperature, salinity or other non-living stresses, as opposed to biotic stresses such as insects or plant diseases. The center will also pursue adaptations to stabilize feedstock supplies for agricultural and biorenewable industries.

The center has a number of clearly delineated goals, Kirby notes:

- Public/private partnerships to commercialize emerging technologies, testing them under South Dakota's rigorous conditions with the ultimate goal of providing innovative genetic material to producers and industry more rapidly.
- New commercial enterprises that will expand the base of high-technology innovation and commercialization in South Dakota.
- Specific genome-based solutions to ameliorate the effects of climatic and abiotic stressors on key agronomic crops, par-

Governor Mike Rounds pledges support for first building in first research park in South Dakota at groundbreaking ceremonies.

Grape growers the world over are following Anne Fennell's research. If extreme cold in South Dakota chills vines before they can become dormant, moderate temperatures in other areas may not be cold enough to signal the grapes to break dormancy.

ticularly those crops for which limited commercial genomics activity is occurring (wheat, oilseeds, short-season soybeans, etc.).

• Identification of genes associated with drought, temperature, disease resistance, crop quality, and key traits for the rapidly emerging biofuels feedstocks industry.

Funding sources for the flagship building that will house the 2010 Research Center for Drought Tolerance Biotechnology include $2.5 million from the Economic Development Administration (an agency of the U.S. Department of Commerce), $1.5 million from Vision Brookings (a coalition of economic development organizations working to create opportunities for generating new jobs and improving quality of life in Brookings), $310,000 from the Crop Improvement Association, $496,000 from a HUD grant, and $500,000 from the State of South Dakota.

The master plan for the 125-acre Innovation Campus at SDSU calls for 19 buildings, with a combined total of more than 1 million square feet of space. The plan includes a long-term private investment of more than $200 million to complete the build-out of the research park.

MAJOR NEW AGRICULTURAL RESEARCH PROJECTS

at SDSU also are are attracting research dollars along with national and international interest.

Grape growers that SDSU professor Anne Fennell works with in South Dakota have a perennial problem: Extreme cold makes it essential to choose vines that can endure climate extremes by entering dormancy before South Dakota's sometimes bitter winters set in.

But researchers Fennell works with in southern France and Israel say their growers deal with the opposite problem: Temperatures may not be cold enough to fulfill the chilling requirement to break dormancy.

The problem is as wide-ranging as the climate extremes. That's partly why the National Science Foundation awarded a $3 million grant to allow Fennell to examine the biological mechanisms involved when grapes enter or break dormancy.

Fennell is the principal investigator and SDSU is the lead institution for a team of researchers from three other universities who will use a genetic model system that Fennell developed. From the research will come advances in selecting and breeding grapes for different climates and improved practices

"We're constantly working to integrate basic science, genomics and new frontiers into agricultural research. … I look at this and say, 'How are we going to enhance our ability to support farm production in the state for the long haul?' This is one of those areas."

—John Kirby, director,
SDSU Agricultural Experiment Station

for managing dormancy in existing grape cultivars.

"There are worldwide applications for this type of research," says Fennell, of the Horticulture, Forestry, Landscape and Parks Department.

"Here in the Upper Midwest the timing of the induction of dormancy is important for winter survival. In southern France and in Israel, the warm climate can be a problem. It causes a delay in dormancy release and bud break, which can impact timing in terms of market or favorable environment for production."

To see South Dakota grape growers' issues in a global context and then to assemble a team of researchers who can address them is praiseworthy, says South Dakota Agricultural Experiment Station Director John Kirby. Other investigators working with Fennell in the project are Karen Schlauch of Boston University; Grant Cramer of the University of Nevada-Reno; and Julie Dickerson of Iowa State University.

DORMANCY AFFECTS WINTER SURVIVAL, says Fennell.

"When does the plant shut down and when does it wake up, and how does that relate to the environment? That's controlled by the genetics of the plant, as well as the interaction with the environment," she says.

Fennell explains that some grapes are temperature-sensitive, some are day length-sensitive, and some use both temperature and day length as signals for entering dormancy.

Initially Fennell will compare two very different species, one sensitive to day length and one not sensitive to day length. She also will look at how the progeny from those lines, though genetically very closely related, respond to different environmental cues in regard to dormancy.

Kirby said the award means SDSU will be a lead institution studying abiotic stress in grapes, particularly the issues of how temperature and day length affect dormancy.

"We're constantly working to integrate basic science, genomics and new frontiers into agricultural research. Anne has been working with grapes for many years and has developed valuable resources through very careful science," Kirby said. "This is an exciting time for us, to see someone who has put in all the legwork and all the hard background work to now get recognized to do the real cutting edge work."

Gary Lemme, dean of SDSU's College of Agriculture and Biological Sciences, says the award points to the importance of specialty crops as South Dakota agriculture presses into the 21st century.

There are already at least seven active farm wineries in South Dakota, Lemme notes, which generate substantial revenue though only about 70 acres in the entire state are now devoted to growing grapes. Fennell's groundbreaking research will not only benefit those northern growers, but grape growers around the world, he adds.

"This award by the National Science Foundation is a recognition of the quality science that is being conducted here at South Dakota State University," Lemme says. "Dr. Fennell should be complimented for developing the team of scientists from other universities to work with her so that we're doing fundamental science to promote the economic development of South Dakota."

HOW FARMERS COULD PERHAPS MAKE it easier for the rest of us to meet the challenge of climate change is part of another major research project at SDSU.

Distinguished Professor W. Carter, also from SDSU's Department of Horticulture, Forestry, Landscape and Parks, said climate change may mean fewer ducks on South Dakota's skyline and less diverse wildlife on the ground as wetlands shrink. And that ultimately could pose changes for people living on farms and rural communities as the climate shifts around them.

That's what's behind the Environmental Protection Agency's announcement in August 2006 that it has awarded South Dakota State University $856,574 to study climate change and land use on biodiversity in the Prairie Pothole region of the northern Great Plains.

Director Kirby says Johnson began assembling and fine-tuning models to study climate impacts on wetlands starting in 1992 at Lake Cochrane, building on an earlier SDSU study at that site. Johnson has studied wetlands since 1988.

"This is based on years and years and years of dedicated work in developing the models, in fitting the data, and then letting the data speak for itself. We're very fortunate to have that capacity here at SDSU," Kirby says.

He added that Johnson's work is especially valuable in that it can help South Dakotans to prepare for what may be in store in the future.

"A lot of the big problems we need to look at are 10, 20, 50, 75 years down the road, and it's not always easy to do that. I look at this and say, 'How are we going to enhance our ability

to support farm production in the state for the long haul?' This is one of those areas," Kirby says. "This work will help not only the farmers in South Dakota, but those who like to duck hunt, or come here to live and have a better quality of life.

"Without water, we don't live."

WATERFOWL AND AMPHIBIANS, as two of the groups of organisms most likely to be affected by climate change, will be the focus of the 3-year study. Although Johnson, an ecologist, has not specifically addressed climate change with amphibians before, his ongoing work with waterfowl generated keen interest among other scientists when he and his colleagues published their work.

"Ducks are the 'currency' people care about in wetland studies," Johnson says.

"There's a lot of interest in these studies just about everywhere. Minnesota's really interested because their duck hunting has really dropped off, and so has hunting in Arkansas," Johnson says.

"Arkansas shoots the ducks we produce up here. They want to know what's going on in the breeding grounds. We're telling them with this that it doesn't look really promising in the future if the climatologists are right.

"We're not forecasting anything about the climate. We're taking the projections and applying them to our model."

The Prairie Pothole region includes nearly 1 million square kilometers in parts of the Dakotas, Minnesota, Iowa, and the Prairie Provinces in Canada. Historically it's been one of the world's great nesting grounds for waterfowl.

But Johnson's work with wetland models up to this point suggests that even a rise in temperature of 3 degrees Centigrade might be enough to make that historic "duck factory" vanish from much of the Prairie Potholes. Some of Johnson's work to date suggests that the ideal conditions for waterfowl would shift to the eastern fringe of the Prairie Pothole region, where many wetlands have already been drained. Other parts of the pothole region could become drier.

THE EPA HAS AWARDED JOHNSON one of its Science to Achieve Results (STAR) research grants to study that problem. The project will identify possible future climatic and land use conditions that could sharply reduce biodiversity in wetlands across the Prairie Pothole region.

Johnson will use a computer model that simulates the dynamics of wetlands to examine the way prairie potholes respond to climate change and farming practices. Johnson said it's important to note that the project also will look at how land management can potentially offset the severity of climate change.

"Some people have said, 'What could we possibly do about this? If our climate is going to get warmer and drier, we're just going to have to sit here and take it.'

"But we've been doing some model simulations that suggest that if you farm differently around wetlands, you can impact the water levels of wetlands. Some crops use more water than others. Some allow more water then to enter the wetland through runoff or groundwater seepage. If you shifted crop types, you could actually ameliorate, up to a certain point, the impacts of climate change—we think by about 2 degrees Centigrade. So if you switched, for example, from row crops to managed grassland, or even to wheat, you would conserve water in the wetland. Tillage practices also are an impact."

CLIMATOLOGISTS ARE IN AGREEMENT that South Dakota's stretch of the Prairie Pothole region could see a 3- to 4-degree Centigrade rise in temperature over the next 50 years, or certainly over the next 75.

"If this really got to be important and we really began to see these impacts taking place and people were concerned about them, we could write something into the farm bill to make modifications and encourage farmers to use one kind of crop or another. That's a ways down the road, of course, and we don't have as much support as we'd need for that, but it's an interesting idea."

Johnson is cooperating with colleagues at Oregon State University at Corvallis in the research. The project also involves the U.S. Geological Survey (Patuxent, Md.); the U.S. Forest Service (Grand Rapids, Minn.); and the U.S. Department of Agriculture's Agricultural Research Service (Temple, Texas).

The project was one of only six grants EPA awarded nationwide in response to a request for research proposals. The projects look at nonlinear responses to global change in linked aquatic and terrestrial ecosystems and the effects of multiple factors on terrestrial ecosystems.

This is the second major EPA grant Johnson has won to study climate change and wetlands. He also won a major grant from the U.S. Geological Survey to study the same topic. All told, his work in this area has brought in nearly $2 million in research funding to SDSU.

MAJOR IMPACTS FOR THE PEOPLE of South Dakota will evolve from four grants totaling about $400,000 recently won by faculty in the Biology/Microbiology Department.

Professor Nels Troelstrup has received a $256,884 grant from the Environmental Protection Agency, funneled through the state Department of Environment and Natural Resources, to monitor and assess intermittent headwater streams in eastern South Dakota.

Conservative estimates suggest that small streams drain more than 70% of land area within the U.S. and contribute directly to downstream water quality and habitat conditions. The EPA is encouraging states to focus greater attention on

Nels Troelstrup, standing, will identify "best of the best" streams in eastern South Dakota in terms of their water quality.

conservation and proper management of headwater drainages.

The funding provided by this grant will be used to identify reference headwater streams in eastern South Dakota. Reference sites represent the "best of the best." Their defining characteristics serve as benchmarks against which other streams are measured. This project will utilize geographic information system technology and field sampling to document the water quality, physical habitat, and biological characteristics of these reference streams.

Professors Gary Larson and Tom Schumacher (Plant Science) and Distinguished Professor Doug Malo (Plant Science) will enlarge a study of the Ruby Gulch waste rock repositorymonitoring vegetation establishment and succession and soil development on the 70-acre terraced cap covering mining waste rock created by Gilt Edge Gold Mine operations in the Black Hills. The $72,779 grant is from U.S. Bureau of Reclamation and the EPA.

Professor Bill Gibbons has received $38,752, for a multi-fermentor system for bioprocessing research. The USDA equipment grant dollars are matched by contributions from the South Dakota Agricultural Experiment Station, the SDSU Department of Biology/Microbiology, and the South Dakota Corn Utilization Council.

The multi-fermentor is a single unit with six small 500-milliliter fermentors, allowing scientists to run several replications of treatments at the same time. The equipment essentially triples SDSU's capability to carry out certain types of experiments.

Professor Charles Dieter will use $31,000 to evaluate habitat use and requirements for grassland bird species of greatest conservation need in central and western South Dakota. The project will focus on grassland bird species that may be on the decline as the acreage of grassland habitat decreases.

He will be determining best nesting habitat for various species. The other principal investigator on the project is Kristel Bakker from Dakota State University, and the full amount of the project is $99,000 through the South Dakota Department of Game, Fish and Parks (a State Wildlife Grant originally funded by the U.S. Fish and Wildlife Service).◆

—Lance Nixon

Mystery substance in beef cattle also found in humans, says Aimee Wertz-Lutz.

HUNGER SIGNAL?

A hormone that seems to help beef cattle regulate their appetites and control the way they respond to feed is losing its mystery.

Aimee Wertz-Lutz, assistant professor in South Dakota State University's Animal & Range Sciences Department, says that scientists have known for years that cells in the anterior pituitary of humans and some other mammals have "receptors" that are triggered by some unidentified substance to secrete a growth hormone.

A receptor, in biochemistry terms, is a protein on the cell membrane or within the cytoplasm or cell nucleus that binds to a specific molecule called a ligand (such as a hormone or other substance), initiating some response—in this case, the release of a growth hormone.

In 1999, scientists named the newfound hormone triggering that response "ghrelin" (gray'-lin) because of its connection to growth hormone secretion. (The "ghre" part of the word means "grow.")

Ghrelin is found in humans as well as various livestock and rodents, so there is widespread interest in what the hormone does.

"We think that this hormone may help cows to sense the inadequacy or the abundance of feed resources."

—Aimee Wertz-Lutz, SDSU assistant professor,
SDSU Animal & Range Sciences Department

"It's very similar across species," Wertz-Lutz says. "The hormone is produced by the gastrointestinal tract, but it communicates with the brain and may serve as a signal of what's going on in other parts of the body."

Wertz-Lutz adds that in addition to the gastrointestinal tract, ghrelin has been found to a lesser extent in the kidney, hypothalamus, pituitary gland, placenta, and immune cells. The fact that it is produced in multiple sites makes scientists believe it has more than one function.

Though Wertz-Lutz is interested in how the hormone affects beef cattle, she says the knowledge obtained from work with the hormone has broad applications to other animals such as swine, sheep, and dairy cattle. She adds that the same hormone is being studied in humans as a factor in human diet.

GHRELIN IS NOT GROWTH HORMONE, but it results in the secretion of growth hormone and also may affect growth by stimulating appetite, Wertz-Lutz explains. One of SDSU's first research projects looked at how ghrelin levels fluctuate with feed intake in cattle.

"We needed to demonstrate that it was related to feed intake," Wertz-Lutz says. "What we found is that when we fasted cattle, we got a six-fold increase in ghrelin in the blood."

She notes that ghrelin, which increases under fasting, appears under conditions that seem directly opposite to those favoring production of insulin, which goes up with feed intake.

Ghrelin stayed elevated in the blood for the entire 48-hour period of the experiment, Wertz-Lutz says. Other researchers have shown that ghrelin levels in fasting swine stayed elevated for 48 hours, then declined.

SDSU's next experiment is to see what happens over a longer term when cattle are put on a 21-day diet on which they lose weight. Initial observation suggests that the cattle exhibit aggressive, "wanting-to-eat" behavior over the first days of the experiment, then settle down.

"We think that this hormone may help cows to sense the inadequacy or the abundance of feed resources," Wertz-Lutz says.

That raises possibilities that certain genotypes of livestock may be better suited for drought-prone regions because of their ability to adapt to limited feed resources, she adds. Ghrelin may play a role in the ability of cattle to adapt to inadequate feed. But it may be years before ghrelin research yields such practical results.

In a third SDSU study beginning in fall 2006, Wertz-Lutz and SDSU Distinguished Professor Robbi Pritchard, a beef nutritionist, put beef cattle on a diet that allows them to grow at a slow rate of gain and then on a diet that lets them gain weight rapidly to make up the difference.

Both ghrelin and leptin concentrations are part of that study, as well as insulin and growth hormone levels because these hormones are believed to influence body composition. The study relates hormones to growth rate and body composition in animals where age and genetic background are controlled.

Wertz-Lutz explains that leptin, which is produced by the fat tissue in the body, seems to work in an opposite fashion to ghrelin—when one is high, the other is low. Leptin has been identified as a hormone that signals satiety, while researchers believe ghrelin may signal hunger. By studying the concentrations of both ghrelin and leptin, Wertz-Lutz says, researchers will have a better idea of how feeding management affects the quality of the carcass.

IT'S TOO EARLY TO SAY exactly how ghrelin may be used in the cattle industry, but Pritchard speculates that it may be useful in situations in which producers want to make animals eat more so that they maintain or gain body condition.

"I have a feeling that in the long run it could have a lot to do with managing our cows. This hormone may be involved in making her eat more so she won't get thinner," Pritchard says. "It's an interesting aspect of compensatory growth in cattle. It's probably going to have applications in beef cows as well as dairy cattle."

Already SDSU's experiments to date show some positive results that may lead to practical applications, Wertz-Lutz adds. SDSU scientists know that administering ghrelin to livestock results in an increase in the time spent feeding and increased feed intake while the hormone is being given.

Future research at SDSU and other land-grant universities will help the beef industry pin down exactly how to make use of ghrelin. Wertz-Lutz is administering the ghrelin to animals through a catheter in the neck, she points out, which is not a practice that would work on the farm.

"We have to find a means of delivery that makes it more producer-friendly, and I think we need a little more research to prove that there would be some practical benefit to producers."

She adds that the Center for Veterinary Medicine, a branch of the federal Food & Drug Administration, would have to approve ghrelin for use by ordinary producers. So far it is only approved for use by researchers. The USDA is keenly interested in ghrelin and has been a major source of funding for Wertz-Lutz's ongoing research through grants from the Cooperative State Research, Education, and Extension Service (CSREES).◆

—Lance Nixon

Pink tags on the map show where Don Evenson has traveled in recent years to participate as invited speaker at fertility conferences and to set up labs similar to the Brookings SCSA facility.

TIME
waits for no man

Gentlemen: The clock ticks for you.

You thought only your wife had a biological clock. That you were fertile up into your golden years and that any miscarriages or children with birth defects were the fault of an aging woman who had ignored the ring of the alarm.

Not so, says Don Evenson, distinguished professor of biology (retired) at South Dakota State University. "A high number of spontaneous miscarriages can derive from the father even if the mother gets the blame."

Associations have been found between genetic defects—mostly behavioral disorders including schizophrenia, autism, mental retardation—and older fathers. Children born to fathers conceiving at the age of 40 to 44 have a twofold higher incidence of schizophrenia compared to children of men conceiving at age 25 and under. For autism the rate appears to be nearly five times higher for men conceiving in the age range of 40 to 44 compared to men conceiving under the age of 29.

The age/sperm DNA damage connection is the newest of these studies and came from Evenson's research, conducted in tandem with the Lawrence Livermore National Laboratory and the University of California, Berkeley. The published report brought the team publicity from around the world.

"It's still possible for scientists who aren't exactly household names to shake up the international press," Evenson observes wryly while running his computer mouse over headlines from medical and scientific journals, Fox News, National Geographic News, ABC, MSNBC, the BBC, the Chicago Tribune, New York Times Sunday magazine, and scores of other newspapers and magazines from around the globe.

Evenson may not be a household name. It is, however, a name with an international reputation, and he is called to conferences and reproductive labs on six continents on a regular basis.

MEN MAKE NEW SPERM CELLS throughout their lifetimes at the rate of about 100 million sperm per day, and the chances increase for genetic material to wear out as it is duplicated over and over again.

"It seems such a simple concept," says Evenson, "but the medical journals up to now said the quality of sperm DNA didn't relate to the age of the man. Now we know better."

Evenson's lab, "half SDSU and half private business," conducted the assays that were the heart of the research. Back in 1980 Evenson had already pioneered research that measured damaged DNA inside the sperm cell itself. Now, after 25 years of experience examining over a hundred thousand animal and human sperm samples, the Brookings lab is the gold standard in sperm DNA fragmentation analysis.

The news that sent reporters scrambling for their pencils and recorders was based in large part on the findings from the Brookings-based lab, now known as SCSA Diagnostics. Men in their early 20s had a low background level of sperm with fragmented DNA, in the range of 3 to 5% of the total sperm in a semen sample. This percentage steadily increased up to ages in the 40s, to about 25%, still below a clinically derived statistical threshold of about 30%.

When men have 30% or more damaged sperm, they fit into a statistical group that takes longer for couples to achieve a natural conception and they will have higher rates of spontaneous miscarriages or no pregnancy.

To Evenson, this was not unexpected news. Years before, he had developed the DFI (DNA Fragmentation Index) as the percentage of sperm in a sample with elevated levels of DNA fragmentation. The threshold is 30%. Data from thousands of donors over the years showed that samples with less than 30% of the sperm with DNA fragmentation had higher probabilities of contributing to successful pregnancies, compared with samples over 30%.

THE "NEW" FINDING WAS THE LINK of DNA damage with age.

The Livermore research results were released in 2006 under the unwieldy title of "Advancing age has differential effects on DNA damage, chromatin integrity, gene mutations, and aneuploidies in sperm." Published in the Proceedings of the National Academy of Sciences, the study was the first to model the effect of age, even of healthy donors, on DNA fragmentation and to estimate the magnitude and shape of the age relationships.

The scientists reported no strict age thresholds but rather a gradual upward trend in the average frequency of sperm with broken DNA, always, of course, with a few men in early years exhibiting considerable breakage and a few in their 70s with predominately healthy sperm.

"There are many factors—disease, diet, drug use, fever, air pollution, smoking—[that cause sperm DNA breakdown]. Most of these are temporary, and sperm quality may improve over time. But there's no improvement when age is concerned."

—DON EVENSON,
SDSU DISTINGUISHED PROFESSOR OF BIOLOGY (RET)

The men chosen for the study were as alike as possible—except for age—to eliminate other factors that influence sperm quality. All men worked at or were retired from the Lawrence Livermore Lab. They had no infections, no significant factors for infertility, and no exposure to any radiation, were not smokers, and declared themselves in good health. They ranged in age from 22 to 80, the 97 of them nearly evenly divided into 10-year classes.

The average percent of broken DNA more than doubled between 20 and 60 years of age and increased fivefold between 20 and 80.

BEFORE SCSA AND THE FLOW CYTOMETER came along, all this would have been guesswork.

"Other fertility tests simply examine the outside of sperm cells," Evenson says. "We look at the inside of the nucleus, i.e., the critically important paternal genetic contribution to the development and health of a child."

The "outside" measures of male fertility are number of sperm in a sample, their appearance, and how much they wiggle under the microscope. Typically, sperm lose the ability to swim in a straight line in an aging male.

"These are subjective measures and all external measurements," Evenson says. "The amount of 'wiggle,' for example, depends in part on the person looking through the microscope on a particular day."

The flow cytometer in the SCSA lab, not being human and subject to human inconsistencies, changed all that.

"It has power in numbers, it has power in objectivity, and it has power in speed and precision," Evenson sums up.

"Our assay is the first computerized, instrumentation-based system able to measure sperm DNA integrity in 200 to 300 individual cells per second. We can examine the integrity of the nuclear DNA in each one of those cells. The assay gives us a better understanding of the probabilities of achieving a pregnancy."

A sample of sperm gets a half-minute acid bath. But if the chromosomes are damaged, even 30 seconds in acid will expose the unraveled double-stranded DNA.

Then a fluorescent dye is added, and the sample is streamed through a glass channel that intersects a laser beam in the flow cytometer. Cells with normal DNA will fluoresce green, damaged cells will show up in 1024 shades of red—the higher the number the greater the degree of damage.

These data are recorded in an interfaced computer, and out of the printer comes a graph documenting the SCSA results. These clinical data are then sent to the physician that ordered the test or, in this case, to the Livermore Lab scientists.

AGE IS NOT THE ONLY CAUSE of sperm DNA breakdown, Evenson says. "There are many factors—disease, diet, drug use, fever, air pollution, smoking. Most of these are temporary, and sperm quality may improve over time. But there's no improvement when age is concerned."

Couple that, he says, with national studies showing that increasing numbers of men are waiting to parent. Since 1980, there has been about a 20% decrease in fathers under 30 and a 40% increase in older (35 to 49) fathers.

"So there's the possibility of more miscarriages and birth defects. And the possibility that the man will be the oldest father at his kid's high school graduation. Maybe Mother Nature had it right. We need to be young to father children and—something we parents all learn—to keep up with them as they grow." ◆—*Mary Brashier*

The South Dakota Ag Experiment Station, Environmental Protection Agency, and the USDA partially funded the Livermore study. SCSA Diagnostics, Inc. is one of several enterprises initiated on the SDSU campus that, under the mission of the University to support economic development in South Dakota, has become independent. Evenson retained his professorship until retirement September 30, 2006, and is now an emeritus professor, thus retaining his connection to SDSU. He reported back to work at the lab the next working day.

How long can it go on?

Things are going great—for now. The turkey populations are healthy and stable. The scenery is spectacular. And there aren't so many hunters that they are crowding each other off the roads or usurping another's calling tree.

That's the spring turkey season in the Black Hills. Could things change?

Well, yes, says K.C. Jensen, associate professor in the South Dakota State University Wildlife and Fisheries Sciences Department.

"There are already some indications that the hunting experience is not what it was some years ago."

Proving that is another matter and is why Jensen and Ashly Steinke, graduate research assistant in the department, set out to discover the connection between hunting and turkey mortality and gather some baseline data with which to compare future statistics.

"We follow turkeys around all year anyway, but we were particularly concerned about the spring hunting harvest, which is for gobblers only," Jensen says.

"What we found out was that somewhere over 73% of annual mortality of toms in our Black Hills study area was due to spring hunting."

That compares to 50, 33, 59, and 30% in other prime turkey hunting states. The difference may be that South Dakota issues unlimited licenses for Black Hills turkeys.

THAT'S A DRAW FOR HUNTERS. Hunters in the Black Hills have increased by about 97% since 2000, from 3,374 to 6,656, or about 11% a year. The National Wild Turkey Federation estimates that 60% of hunters are nonresidents and says that in 2004, for example, spring turkey nonresident hunting licenses topped nonresident deer tags by over a thousand.

"Another attraction for hunters, adds Steinke, "is that over 50% of the land in the Black Hills hunting unit is open to public hunting.

Here is also the place to bag the Merriam's turkey. "Fortunately, Merriam's in the Hills are more productive and can sustain higher annual harvests than other populations of this wild turkey subspecies."

Chad Lehman, National Wild Turkey Federation regional biologist, left, and Steinke radio-collar a Merriam's turkey. This and cover photo from K.C. Jensen; other photos courtesy of Lehman.

The Merriam's is the "trophy bird" for many nonresident spring turkey hunters looking for an adult male with a long beard. He would round out the grand slam, as hunters call it, of bagging one of each of the five subspecies of turkeys from different places in the country.

Hunter success has ranged from approximately 30 to 45%, for an average annual harvest of 2,000 to 2,500 toms every spring season, says Steinke.

HOW LONG CAN THIS GO ON?

"For the moment, the turkey population can take the pressure," Jensen says.

"Granted, it skews the population to a high proportion of young males, but jakes are perfectly capable of reproducing."

A jake is a young male from the time his beard just becomes visible to the start of his second winter.

Also contributing to a sustainable turkey population, says Les Flake, Distinguished Professor Emeritus in the SDSU Wildlife and Fisheries Sciences Department and senior author of a recent book, The wild turkey in South Dakota, is the annual survival of hens, near or above 70%, about the highest rate in North America. Hen survival provides a measure of habitat quality, and in the Black Hills the habitat is not only scenic, it is excellent for Merriam's turkeys.

Hens may be hunted only during the either-sex season in the fall, which is just a week long. Spring turkey season is for males only and in 2007 runs from April 14 through May 20.

DOWN THE ROAD, says Jensen, "there could be some problems in terms of hunter satisfaction.

"If they come to the Hills only to bag a grand slam tom, they might have to hunt harder and longer and might not be successful. A mature male gobbler of 3 years or more in the Hills is already a rare creature.

"And if the number of hunters keeps increasing at the annual 11% rate, we could come to the point where people with guns are getting in each other's way. At best, there's dissatisfaction with the hunt. At worst, there's a hunting accident.

"We're already starting to see a backlash—resident hunters are beginning to be aggravated that there are so many out-of-staters."

But that's a sentiment that could backfire on the locals. Chad Lehman, National Wild Turkey Federation state biologist, estimates that turkey hunters spent nearly $2.8 million in 2004 in the Black Hills. Since 60% of the hunters were nonresidents, they left about $2 million behind when they returned home.

That's welcome income in the spring when the summer tourists and winter skiers aren't around.

"So the first thing we needed to find out," says Jensen, "was the amount of mortality due to harvest from hunters during

"If hunters keeping increasing... and they keep harvesting at high rates, we're going to have problems. Ashly has already picked up some dissatisfaction that contrasts with opinions from earlier years... Maybe it will self regulate. If not, we have some data that will help us adjust license numbers or take other steps to keep a healthy, sustainable turkey population in the Hills."

—K.C. Jensen, associate professor,
SDSU Wildlife and Fisheries Sciences Department

the spring turkey season. Strange to say, we didn't know, although there have been studies on annual mortality."

FOR TWO WINTERS, Steinke leg banded and radio marked Merriam's toms in the study area of Custer and Fall River counties in the southern Black Hills. From data retrieved after the spring hunts, he reported that annual total survival rate of 42% over the study years was similar to or slightly lower than for Merriam's and Eastern wild turkey gobblers in the upper MidWest and that 73% of the total number of toms that died were taken during the spring hunt. Fall hunting had no significant effect on survival.

The southern Hills, site of the study, and the northern Hills tend to harbor Merriam's turkeys with two different mindsets, Jensen adds.

The northern Hills is mostly public land; the southern Hills has more private property. Turkeys in the southern Hills remember where to go when the weather closes down—to the farmyards and hay bales of landowners. "We wouldn't have so many turkeys this far north in their range if it weren't for private landowners providing supplemental feed during the winter, whether they intended to or not," Jensen says. "And during hunting season, these birds tend to be more protected by 'no trespassing' and 'no hunting' signs."

Turkeys in the northern Hills, on the other hand, tend to disperse more and eke out a living eating mostly pine seeds. In the hunting season they are more vulnerable because they're on public land where the hunters can get at them.

That sends a signal to Jensen.

"Maybe we're actually harvesting the wilder and 'good' birds at a higher rate than the problem birds, the ones that can spark landowner complaints because they foul up the cattle feed.

"We have plans to expand this study into the central and northern Black Hills to examine this and to enlarge our data base on springtime tom turkey mortality.

"If hunters keeping increasing at 10 or 11% per year and they keep harvesting at high rates, we're going to have problems. Ashly has already picked up some dissatisfaction that contrasts with opinions from earlier years when he interviewed hunters.

"Maybe it will self regulate. If not, we have some data that will help us adjust license numbers or take other steps to keep a healthy, sustainable turkey population in the Hills."

Funding for the project came from the South Dakota Game, Fish and Parks Department, the National Wild Turkey Federation, and the South Dakota Agricultural Experiment Station.◆

—Mary Brashier

BSL3-AG LAB sought for SDSU

The proposal from the South Dakota State University Animal Disease Research and Diagnostic Laboratory (ADRDL) is to construct, at a cost of about $20 million, a high-containment, 24,000-square-foot addition that would contain BSL 3 and BSL3-Ag diagnostic and research space. Biosafety Levels (BSL) refer to facility design and laboratory practices to meet certain needs.

BSL 1 facilities work with well-characterized agents not known to cause disease in healthy adult humans. These agents have minimum potential hazard to lab personnel and the environment.

BSL 2 facilities are similar but are suitable for work with agents of moderate potential hazard to personnel and the environment. The Animal Disease Research and Diagnostic Laboratory at SDSU is currently a BSL 2 facility.

BSL 3 facilities are those where clinical, diagnostic, teaching, research, or production work is done with indigenous or exotic agents that may cause serious or potentially lethal disease as a result of exposure by inhalation.

BSL3-Ag facilities include the containment features of BSL 3 facilities and are specially designed to protect the environment from the escape of high-consequence livestock pathogens. The USDA must certify these facilities.

THE NEW ADDITION FOR THE ADRDL would mean added safety for lab personnel, the public, and the environment, and it would also bring a new level of opportunity and

"The high-containment laboratory does two big things. It allows us to make sure that the dangerous specimen, once it gets to the lab, is contained in the lab and doesn't escape to the outside. … The second big thing it does is protect our employees."

—DAVID ZEMAN,
SDSU ADRDL DIRECTOR

"This will not be just a fire engine building," says David Zeman.

responsibility, says ADRDL Director David Zeman, who also heads the SDSU Department of Veterinary Science.

BSL3-Ag and BSL 3 containment facilities are important when doing diagnostic and research work that involves dangerous pathogens that cause diseases such as avian influenza, anthrax, foot and mouth disease, hog cholera, West Nile virus, and prion diseases such as mad cow disease and chronic wasting disease of deer, Zeman says. "In high volume outbreak situations, such facilities are necessary to ensure safety to our employees and the surrounding environment," he adds.

"The high-containment laboratory does two big things. It allows us to make sure that the dangerous specimen, once it gets to the lab, is contained in the lab and doesn't escape to the outside. All the air that leaves the building is filtered, all the water from the high-containment unit is caught and treated on site before it's released into the sanitary sewer system," Zeman says.

"The second big thing it does is protect our employees. The Biosafety Level 2 lab that was added to our complex in 1994 is a very good lab; however, it's not a high-containment lab. Since 1994, animal health labs have been dealing with more and more high risk pathogens."

Zeman says the added level of safety is crucial for employees and the public, especially when working with zoonotic pathogens—those causing diseases that can leap from animals to humans—such as the agents that cause bird flu and mad cow disease.

WHAT'S MORE, "AN ESTIMATED 75% of the most feared bioterrorism agents are zoonotic pathogens," Zeman says. The upgraded ADRDL would be better equipped for its role as part of a national network of labs helping to monitor the nation's biosecurity and health of its food producing animals.

"We cannot dismiss the potential, even in South Dakota, for the malicious introduction of highly pathogenic foreign animal diseases, weaponized disease agents, or zoonotic agents," Zeman says. "Bioterrorists know that this is a vulnerability and our labs must be prepared to handle both natural disease outbreaks as well as maliciously introduced outbreaks."

Even without the threat of bioterrorism, Zeman says concerns about exotic animal diseases have been growing over the past two decades in the animal health industry.

He suggests several reasons for that: People are traveling more than ever before, which allows greater opportunities for accidental introductions; official agricultural trade across the globe increases the risk of transport of pathogens in animals or animal products; there appears to be an an increase in new diseases among animals and humans; and the public is simply more concerned and more demanding about how labs such as the ADRDL do their work.

THERE WILL BE NO WAITING AROUND for a crisis to happen after the lab is built. ADRDL scientists be taking on additional research duties. The current facility is not adequate for researchers to play a role in improving an anthrax vaccine, for example, says Zeman.

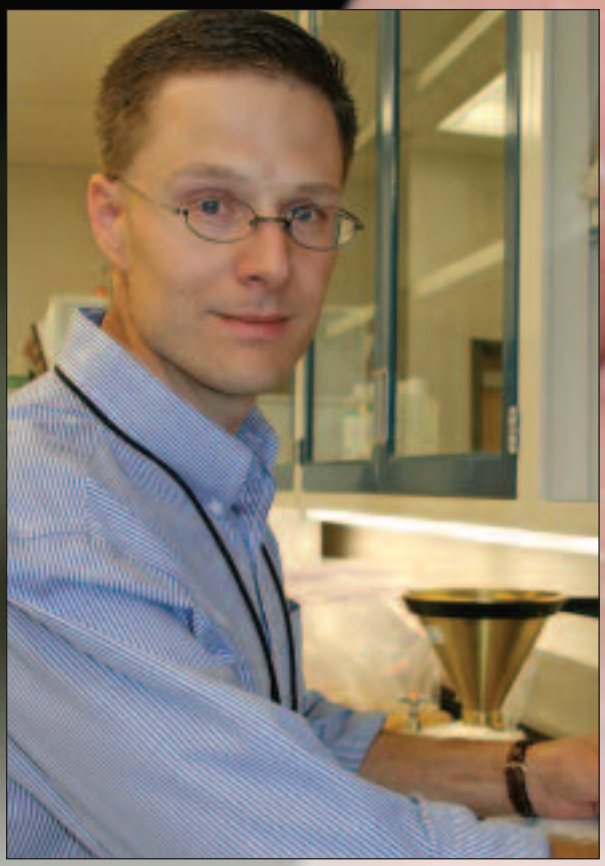
"This would not be just a fire engine building. We have a very strong research program," Zeman says. "We would not be allowed to participate in many of the infectious disease research proposals of the future if we didn't have the proper facility."

The addition would carry an estimated price tag of $20 million. The good news, as far as South Dakota higher education is concerned, is that the money for the upgrade would not be requested from the usual higher education budget.

"The thing people need to understand is that this lab, even though it's on the campus of SDSU and is administered by SDSU and the Board of Regents, is really a piece of state infrastructure, established by South Dakota statute in 1967. We're here to fulfill the mission given to us by the South Dakota Legislature in that year—to provide diagnostic laboratory data for veterinarians, animal owners, and animal health officials, as well as to public health officials. Then we all will know what diseases we're dealing with in the animal population and we all can react and respond accordingly."

The lab has been providing diagnostic services for South Dakota since 1887, Zeman adds, keeping pace through the years with changes in technology and science. The upgraded, expanded facilities would help the lab move forward into the 21st century as animal owners, veterinarians, and the public more closely scrutinize animal disease threats and laboratory activities.

The proposal has support from SDSU, Ag Unity, the South Dakota Veterinary Medical Association, the ADRDL Advisory Committee, the Brookings Economic Development Corp., the South Dakota Animal Industry Board, and several agricultural commodity groups.◆ *—Lance Nixon*



The price is right, says Kurt Rosentrater, for an alternative fish food.

Food fish food?

Livestock. Pets. Now fish.

Research with ethanol co-products at South Dakota State University to date has examined how distillers grains can be part of a nutrient-rich, cost-effective diet for beef and dairy cattle, hogs, sheep, even pets such as dogs and cats.

Now scientists are pursuing a new angle: How does it measure up as fish food?

SDSU researchers have teamed with Kurt Rosentrater, an agricultural and bioprocess engineer for the North Central Agricultural Research Laboratory, the Brookings-based laboratory of the USDA's Agricultural Research Service, to discover if the idea might work.

Michael Brown, SDSU Department of Wildlife and Fisheries Sciences professor, and Rosentrater have used dried distillers grains with solubles (DDGS) in rations fed to Nile tilapia. The two are working with Professor Kasiviswanathan Muthukumarappan and Nehru Chevanan, graduate student in SDSU's Department of Agricultural and Biosystems Engineering to extrude a mix of ingredients with varying amounts of DDGS to get a DDG-based aquaculture ration. DDGS is the main source of protein in those mixes.

THE TILAPIA IS A FOOD FISH, grown in the U.S. primarily in ponds in southern states but also indoors in many north-central states since it is temperature sensitive. It is often advertised as the "new white fish" to replace depleted populations of cod and hake, and it is claimed that only salmon and channel catfish among all aquaculture fishes are consumed at a higher rate in this country. It is the second most important group of farm-raised fish in the world.

"We're basically trying to replace fish meal as a protein source," Rosentrater says. "We've looked at 20, 30, and 40% replacement. Fish meal is an excellent source of protein for aquaculture feeds, but there are concerns about feeding reprocessed animals to the same animal group."

Since the United States this year will produce about 10 million metric tons of distillers grains, it would be a possible protein source for aquaculture feeds. Dairy and beef cattle diets are likely to remain the main uses for DDGS for the foreseeable future, Rosentrater says, though a growing body of research is fitting it into swine and poultry diets as well.

Rosentrater says there's definitely room to explore innova-

"If we can achieve a good ration that fish will respond to, then I think there are going to be benefits for the aquaculture farmers as well as for the ethanol industry."

—KURT ROSENTRATER, USDA-ARS

tive ways to use DDGS, as Muthukumarappan did in an earlier research project looking at DDGS in pet feeds. Rosentrater said he's interested in pursuing more research in those alternative areas with SDSU scientists.

"What we're trying to do here is augment traditional use with alternatives such as aquaculture and pet feeds; human food products; and industrial products."

Kasiviswanathan Muthukumarappan plans a feed with 70 to 80% DDGS.

FISH FARMERS COULD DEFINITELY benefit from a cost standpoint.

"Fish feed right now is about $800 a ton. Distillers grains are currently selling for about $70 to $80 a ton. So there's a tenfold difference in price. If we can achieve a good ration that fish will respond to, then I think there are going to be benefits for the aquaculture farmers as well as for the ethanol industry," Rosentrater says.

Muthukumarappan formulated tilapia diets of distillers grains, cornstarch, soy flour, and minerals and vitamins. The distillers grains made up 20, 30, and 40% of those diets.

"Above 40% we did not get a good product. The product was not bound together at that level, it was dispersing as a powder," Muthukumarappan says.

He explains that as the percentage of DDGS increases, the concentration of starch molecules in the mix decreases.

The scientists searched for something to effectively bind the feed ingredients together, finally hitting on whey protein powder to do the job.

"We could have used some other chemical product to bind it, but whey protein is a natural product and it's one of the waste products coming from the cheese industry," Muthukumarappan says.

In the future, Muthukumarappan would like to look at some other starch source besides corn starch, perhaps potato starch or cassava starch.

"Those starch molecules are different than corn starch and might allow us to have more cohesiveness in the product."

He adds that the processing variables—the amount of moisture and the temperature of cooking during extrusion—also affect the final product. Some fine-tuning in those variables may also help.

"In fact, our future plan is to develop an aquaculture feed product that would have anywhere from 70 to 80% DDGS."

FROM THE STANDPOINT OF THE FISH, the research thus far has been a success.

Brown notes that all the DDGS trial diets were adjusted to 28% protein. The fish on those diets were compared to a control commercial production feed that was 8% higher in protein.

"The 20% DDGS diet is doing as well as the control diet, or possibly even better," Brown says. "We're fairly optimistic that we can get at least 20% DDGS into the tilapia feed. And then by looking in greater detail at some of the different amino acids, we might be able to supplement some that aren't in DDGS and possibly incorporate higher levels of DDGS. That's something we will have to determine by trial, looking at growth, feed conversion, and other performance metrics."

Mel Stocks, president of MinAqua Fisheries of Renville, Minn., a cooperative that raises tilapia, says he wouldn't rule out the possibility of a DDGS-based diet, but that he knows of no one feeding tilapia in tanks who gets by feeding a product that has only 28% protein. Some producers use feeds with that low level of protein if they're feeding tilapia in ponds, he says, because the fish then can supplement their protein by eating algae.

"I'd have to see that it would provide the nutrients I need and that it would be more cost-effective than what I'm doing. If there were substantial savings, I would consider it," Stocks says.

But he adds that the diet he uses already leans heavily on soybean meal for protein and uses only about 6 to 10% fishmeal.

Stocks says that a problem in using DDGS in aquaculture feeds earlier on has been the variability in the product.

Brown agrees that is still a factor to consider.

"Sometimes there's considerable variability in the composition of those DDGS in terms of not only protein and the lipids, which are the macronutrients, but also within them. Are we getting the amino acid and fatty acid profiles that are suitable for the species we're trying to culture? That's what we're looking at now."

Brown says the SDSU-ARS project may begin channel catfish trials with DDGS-based aquaculture feeds in the near future. ◆ *—Lance Nixon*

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