Good Vibrations

Musician-scientists probe the woodwind reed

By KAREN F. SCHMIDT

In the opening to George Gershwin's jazzy orchestral piece, "Rhapsody in Blue," the clarinet's smooth, sexy glissando up from that first note brings goose bumps to many concertgoers. As the music plays, listeners relax to the swank, easygoing melody. But the clarinetist in this plum role rarely rests easy, with one prayer in mind: Play on, sweet reed, in my time of need!

Fretting over reeds affects virtually every musician who plays oboe, bassoon, saxophone or clarinet — and rightfully so. Players invest hours of time and hundreds of dollars in finding a fragile slice of grass stem to either attach to a mouthpiece (clarinet and saxophone) or form into one (oboe and bassoon).

"It takes a lot of time," laments clarinetist Donald J. Casadonte, a doctoral student of music at Ohio State University in Columbus. Like most woodwind players, he buys reeds by the box, shapes each with a knife, then tests them one by one. "Imagine that you sorted through 100 reeds, at a cost of about $150, and you found only two really good ones. You start playing them at concerts — and if you're a professional, that means four to five concerts a week — and then the reeds go bad after about three to four weeks. You're back to square one."

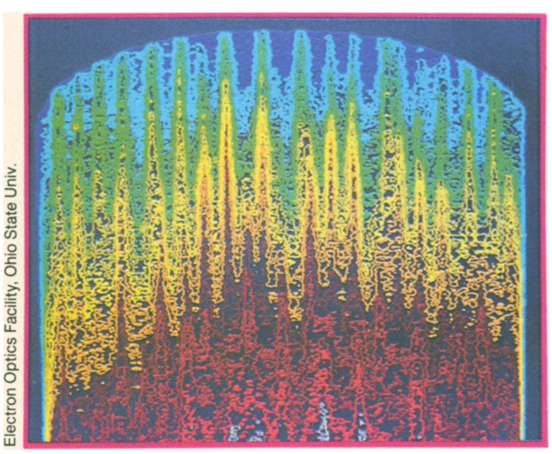
A good reed has a crisp tone over a wide range of notes, is easy to coax and comfortable to play. A bad reed periodically honks like a goose and may require tiring tooth-and-tongue gymnastics to make it behave. Even good reeds go wild and squeaky, or sometimes stuffy and muffled, as they pass their prime — hopefully, *after* the concert.

Although reed anxiety may not make the list of top 10 global problems (or even the top 100), two musician-scientists say woodwind players are terribly frustrated by the scarcity of good reeds these days, and they think it's high time that modern technology offered some help. Casadonte, a clarinet-playing chemist, and Clare Lawton, an oboist and doctoral student in botany and engineering at the University of Reading in England, have thus begun the first comprehensive studies of the reed's physical, chemical and biological properties.

Casadonte and Lawton presented papers at the November meeting of the American Acoustical Society held in Houston. Although they work independently, both researchers hope their findings will improve the lives of woodwind players in several ways: by finding methods to grow better-quality cane for making reeds, by helping musicians identify and preserve good reeds, and by spurring the development of improved substitute materials.

The giant reed plant grows taller and thicker than most grasses. Each plant reaches a height of 7 to 8 feet, but often only one of its 25 or so internode sections possesses the necessary dimensions for an oboe reed.

Many amateur players circumvent the fragile-reed syndrome by using sturdy plastic reeds, "but they sound kind of like a duck with laryngitis," says Casadonte. Professionals remain tied to the original botanical source. The giant reed plant (*Arundo donax*) grows taller and wider than other grasses, making its stems particularly useful to musicians.



An optical densitometer helped bring to life the scraping pattern of this clarinet reed. In this contour map of a reed tip (the part that goes into a player's mouth), colors signify different optical transmissions, or thicknesses of the material.

About 3,000 years ago, Egyptians fashioned *A. donax* stalks into flute-like instruments. At some point, someone discovered that blowing across a small slice of the stem — causing it to vibrate — also created soothing sounds. The earliest depiction of a clarinet-type instrument reportedly appears on an Egyptian relief dated 2700 B.C. Many centuries and many instrument designs later, woodwind players have yet to find a better vibrator than a flimsy sliver of this grass.

To discover what's so special about the dried *A. donax*, Casadonte set out to study its properties. The core tissue of the giant reed plant, he found, orders itself regularly like a crystal; it even chips

Lawton

Cane growers chop the plant stems into sections called internodes, then sort them by diameter. Each woodwind instrument requires a different size of internode for its reed. The farmers send the internodes off to reed manufacturers for final cutting and shaping.

like one. This enables it to diffuse vibrations quite efficiently – a necessary material property for generating musical tones.

Three chemical components lay the foundation, Casadonte explains. Cellulose chains form the crystal lattice, while gummy lignins and moisture-holding pectins fill in structural gaps and act as elasticizers, keeping the reed flexible during its oscillations.

Casadonte examined the chemical makeup of reeds because he wanted to know why they degrade so quickly. He found evidence of three mechanisms that can cut short the lives of good reeds, and all three refute the anecdotal explanations passed along from music teachers to students.

Contrary to music studio rumor, acids in the mouth do not eat away reeds, Casadonte says. For starters, saliva is alkaline, not acidic. But basic saliva could still wreak havoc on the reed's cellulose structure. When Casadonte used infrared spectroscopy to compare fresh reeds with spent ones, he found that spent reeds contain more carbon-oxygen double bonds, which could form by base-catalyzed reactions. Saliva could also leach pectins out of the reed, unmasking hidden carbon-oxygen double bonds, he says. Over time, reeds lose their ability to retain moisture – a fact that supports the theory of pectin-leaching. Casadonte hasn't yet determined whether one or both of these mechanisms are at work.

Bacteria also contribute to reed deterioration. Casadonte found colonies of streptococcal bacteria living inside the walls of the water-conducting xylem cells in spent reeds. The microbes encrust the cells, choking their motion and modifying the vibrational properties of the reed, he theorizes.

Casadonte suspects that the chemical and bacterial breakdown processes exert different effects on the reed's sound quality. Bacterial growth should damp the vibrating reed, just as putting on larger brake shoes makes a car stop faster, he explains. This would mainly affect the faster components of the oscillation, thereby increasing lower frequencies in the tone, he suggests. Chemical degradation, in contrast, would likely enhance a reed's higher vibrational components by making the cell walls thinner and more brittle. Like aging vocal cords, the reed's "voice" would become shriller. In future work, Casadonte plans to explore the deteriorating sound quality of aging reeds to determine which of these mechanisms dominates and how the two interrelate.

Then there's the third mechanism: Casadonte has seen evidence, through X-ray diffraction and infrared spectroscopy, that reeds lose their crystal-like nature with the repeated stress of playing. He theorizes that this loss results from microcracking of the cellulose molecular structure. Although the polymer units may begin to break apart, he says, there's no gross tearing of the material, as many woodwind players believe.

Unfortunately, musicians today have few tricks for preserving their reeds. Casadonte has, however, confirmed the usefulness of one rumored piece of advice: Store reeds in the refrigerator to slow both microbial growth and chemical decomposition.

He also hopes to develop and test several other reed-saving strategies. Applying steam heat to a reed might reverse microcracking by inducing the polymer units to re-link – just a step beyond the moistening and warming up that players now practice to make their reeds flexible. Dipping used reeds into a plasticizer solution might be another way to rebuild the polymer chains, he suggests; a separate antimicrobial dip might flush out bacteria.

The challenge, Casadonte says, is to find chemical solutions that are effective, nontoxic and practical. Otherwise, "by the time you get done treating your reed with all these various solutions, you might rather go out and buy another reed," he says.

In addition to extending the life of reeds, Casadonte's research could help settle a long-standing quibble among woodwind players: What's the best way to scrape a reed for optimal sound vibration?

Players typically hold their reeds up to the light to judge the material's thickness as they carve out patterns evolved from learned tradition – the American and British schools of scraping – and from personal experience. Casadonte takes a more scientific approach to the art of scraping: He uses an optical densitometer to measure the transmission of light through each point on the reed and to construct a contour map consisting of various colors that represent the different thicknesses. He hopes to correlate various reed profiles with their sound quality.

Naturally, how a reed sounds depends on how it vibrates. Having measured the physical properties of reed material, Casadonte is now developing computer software to model the complex motion of vibrating single reeds (clarinet and saxophone) and double reeds (oboe and bassoon). This, he hopes, will allow him to study how different scraping patterns affect the vibrations that govern sound quality. Ultimately, he would like to see novice musicians use computer animation to learn how best to sculpt their reeds.

Casadonte has even tried filming reed action "live" from inside the mouth, capturing the first images of clarinet and oboe reeds vibrating while being played. This project involved a surgical tool called an endoscope – a 2-foot-long optical fiber connected to a videocamera. To obtain the pictures, he snaked the end of the fiber into a player's mouth. He plans to compare the reeds' fluttering motions with a computer model.

While Casadonte has focused mostly on the properties of reeds, he admits that a large part of reed anxiety stems from the dearth of good cane. "Woodwind players are in the hands of individual growers and manufacturers," he says.

That's where his British colleague steps in.

Clare Lawton wondered what made some oboe reeds good and others bad. That compelled her to learn more about the largely unstudied anatomy of *A. donax* and about how woodwind reeds are produced. Hoping to find out why the bulk of the plant's tissue is unsuitable for making reeds, Lawton visited two reed plantations in the Var region of southeastern France.

The plants grow wild in many ditches, she noted in the May 1991 Journal of the British Double Reed Society. Farmers propagate them by burying root clippings, and then let the cane grow for two years. Every January the growers enter the fields, with measuring templates in hand, to check the diameter at chest height of the sturdy, 7- to 8-foot stalks. They harvest those that are at least 10 millimeters – about the minimum diameter required for making instrument reeds – and leave the rest to grow.

Next, the harvested stalks must dry: first stored in a shed from January through June, then sunned from July through September. Finally, the growers chop each stem into its 25 or so sections, called internodes. Because various instruments require different reed sizes, farmers sort the pieces by diameter. Before shipping the internodes to a manufacturer for cutting into the basic reed shapes, they remove any that appear inferior.

These growers base their selections on experience handed down through generations, Lawton says. One expert she met compared the ideal color for a reed interior to the gold of his wedding band. "Part of my work is to relate the things that the growers see to the anatomical features and mechanical properties of the reeds, because I'm not sure [the growers] are always correct," she says.

Lawton has examined tissue slices of "good" and "bad" reeds, and of internodes taken from various heights on the stalk. She observed that the ring of dense, fibrous tissue directly beneath the stem's outermost surface shows the most variation from one internode to the next, suggesting that this may be a key factor in determining reed quality. Furthermore, she found that these rings are thickest near the bottom of the plant, progressively thinning with height.

To her dismay, she discovered that often only one internode per plant possessed the necessary length (72 mm) and thickness (10 to 11.5 mm) for an oboe reed. Moreover, the "oboe internode" could occur at different heights on the stalk – say, position 6 or 12 – depending on growing conditions. Lawton is now nurturing 12 plants back in England to see how controlled environmental conditions affect reed production.

"If I could find the ideal thickness of the cell wall for the oboe or clarinet reed, I could possibly try to cultivate reeds that met that criterion more often," she explains.

Reed quality also varies according to the plant's age, Lawton believes. She's presently comparing the quality of sound production in reeds from one- and two-year-old plants, in hopes of determining the optimum developmental stage for harvest.

Lawton aims to increase the reed supply by encouraging wider cultivation of *A. donax*, which appears to grow well in many climates, including her native England. "For many years – rightly or wrongly – we've held that the best reeds come from France," she says. "What is so special about France? Is it something they do to the cane? Or is it just psychological? I think a lot of it is just habit."

Until now, habit and folklore have shaped musicians' view of the reed, but a new scientific understanding is beginning to take root. Both Casadonte and Lawton envision a day when professional woodwind players will use durable reeds made from a composite polymeric material that closely resembles the traditional *A. donax*.

"I'm hopeful that if enough people get involved in this research, eventually we'll have a nice nontoxic substitute," says Casadonte. "Although I think in the end, it's going to be like the Stradivarius situation, where we can now manufacture violins that are very, very good – but they're not a Stradivarius." Professionals might find the synthetic reeds most useful for rehearsals and reserve high-quality natural reeds for concerts, he suggests.

In any case, an improved synthetic reed and a better supply of natural reeds would do much to alleviate the anxieties of woodwind players. "By the time the 21st century rolls around," says Casadonte, "hopefully woodwind players won't still be sitting around coffee tables complaining about reeds all day." □