

# The Identity and Parentage of the Variety Known in California as Petite Sirah

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DNA marker analysis was used to determine the varietal identity of Petite Sirah in public collections and commercial vineyards in California. Twenty-one vines analyzed from public collections at the University of California at Davis included accessions labeled Petite Sirah, Durif, Syrah and Serine. Fifty-three vines from 26 private Petite Sirah vineyards in four California counties were also analyzed. Several accessions each of Durif, Peloursin, and Syrah obtained from Montpellier, France and an accession of Pinot noir from the University of California at Davis were used as controls for varietal identification. Samples were analyzed with four to eight simple sequence repeat (SSR) DNA markers. Some samples were first analyzed with four DNA probes to detect restriction fragment length polymorphisms (RFLPs). Davis accessions labeled Petite Sirah were found to include vines that we determined to be Durif, Peloursin, Syrah, and Pinot noir. Accessions labeled Durif included vines identical to Durif and Peloursin. The Syrah accessions were identical to the Syrah controls. The Serine accession was found to be Pinot noir. Forty-nine of the 53 Petite Sirah vines from private vineyards were identical to Durif. Four vines, from three vineyards in two counties, were Peloursin. Comparison of the SSR genotypes of Durif and Peloursin indicates that Durif is probably a seedling of Peloursin as reported and cannot be a selection of Peloursin (as also reported). The other parent of Durif is most probably Syrah. SSR genotypes of Durif, Peloursin, and Syrah at 25 loci are consistent with this relationship and likelihood analysis of SSR allele frequencies supports the relationship with a very high degree of probability.

**KEY WORDS:** DNA typing, simple sequence repeat, SSR, microsatellite, restriction fragment length polymorphism, RFLP, variety identification, inheritance, parentage, *Vitis vinifera*, genetics

In France, the name Petite Sirah has been used for several different grape varieties. Both Galet [6] and Chapoutier [5] noted the existence of a 'petite' form of Syrah, preferred over the 'grosse' Syrah because of its lower vigor and yield and higher wine quality. Valat [13] confirmed that old winegrowers were convinced that there was a 'petite' Syrah, prevalent around Hermitage and Côte Rotie, that was better than the 'grosse' Syrah. However, he also reported that in other parts of the Rhône Valley the name Petite Syrah has been used for Durif, a productive variety that was apparently called 'petite' because the plants were weak. According to Galet [7], the name has also been used for the varieties Peloursin and Douce noire.

Given the use of the name for several varieties in France, it is not surprising that the identity of Petite Sirah has been confused in California. According to Sullivan [11], in the late 1800s California plantings of Syrah were called 'petite' Syrah. Later, the name Petite Syrah was also used for Durif and came to be used

collectively for several similar varieties, including Syrah, Durif, Peloursin, and Beclan. Around the turn of the century, when most Syrah vineyards in California were destroyed by phylloxera, it is likely that they were replanted with the other varieties included under the Petite Sirah name in preference over the less productive Syrah. Thus the name Petite Sirah came to be used primarily for grapes other than Syrah. Petite Sirah became an important component of red wines from the California coastal valleys, although its identity remained murky [11]. Today, its acreage has declined, but Petite Sirah varietal wine continues to be produced by a number of California wineries, and it enjoys a devoted following among those who appreciate its deep color, full body and aging potential [9].

The identity of Petite Sirah has remained uncertain for most of its history in California. In 1954, Professor Harold Olmo wrote that Petite Sirah comprised at least three varieties in intermixed plantings [10]. In the 1970s, a visiting French ampelographer examined Petite Sirah vines in California and identified them as the French variety Durif. For many, the issue was thus resolved and word quickly spread that California's Petite Sirah was really Durif. The case was reopened, however, several years ago when we compared the DNA profiles of a number of wine varieties at the University of California at Davis and found that the one Petite Sirah vine we analyzed was clearly not Durif [1].

To more thoroughly investigate the identity of Petite Sirah, we compared the DNA profiles of accessions of Petite Sirah held in collections in Davis and samples

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from commercial Petite Sirah vineyards in California to those of authenticated reference varieties. We obtained authentic samples of several varieties from the INRA variety collection at Domaine de Vassal, Montpellier, France.

### Materials And Methods

**Plant material:** Young leaves and shoot tips were collected from actively growing vines. The Davis material was obtained from the vineyards of the Department of Viticulture and Enology (Tyree Vineyard), Foundation Plant Materials Service, and the USDA National Clonal Germplasm Repository (Table 1). All vines in these vineyards that were labeled Petite Sirah were sampled, whether or not their appearance was consis-

tent with that of standard Petite Sirah. Two vines labeled Syrah were also sampled in order to verify their identity. A vine labeled Serine was tested because of confusion in the literature associated with this name. A Davis Pinot noir vine previously determined (by DNA comparison to an authentic French reference) to be correctly identified was also sampled as a reference. Some vines were sampled in 1992, and these, plus additional vines, were sampled again in 1993.

French material was collected as dormant wood during the winter of 1993 by Dr. Jean-Michel Boursiquot from the variety collection at Domaine de Vassal, Montpellier, France (Table 1). This collection is administered by the Institut National de la Recherche Agronomique and is regarded as the most reliable reference for the identification of French varieties. The wood was transported to Davis and dormant buds were forced in water in a growth chamber. Some French accessions for which healthy green shoots could not be obtained from dormant wood were sampled again during the spring of 1993.

Commercial Petite Sirah vineyards were sampled in 1993 (Sonoma, Napa, Monterey Counties) and 1997 (Mendocino and Napa Counties) (Table 3). While most samples from the commercial vineyards were taken only from vines consistent with the Petite Sirah phenotype, some samples were also taken from other vines that did not look like Petite Sirah. Results for these latter samples will be discussed separately.

**DNA extraction:** DNA was extracted by a modified CTAB protocol as described in Bowers *et al.* [1]. For the French material sampled during the spring of 1993, DNA extractions were performed in Montpellier by Dr. Patrice This, and DNA samples were shipped to Davis.

**RFLP analysis:** Genomic DNA was digested with *Hind* III or *Eco* RV and electrophoresed in 0.8% agarose gels. Southern blotting and hybridization were performed as described in Bowers *et al.* [1]. The blots were probed with grape genomic DNA probes 1A10, 6E8, 4G3, and 3B4 and scored for the presence or absence of 31 reliable polymorphic bands, as previously described [1]. Each distinct RFLP pattern observed was assigned a letter. Some samples were analyzed twice.

**SSR analysis:** DNA samples from all of the Davis and French accessions were analyzed at eight SSR loci—VVMD5, VVMD6, VVMD7, VVMD8 [2],

Table 1. Origin of plant material analyzed.

Sample number	Vineyard label <sup>1</sup>	Accession or selection number	Vineyard location <sup>2</sup>	Origin
<b>Davis</b>				
D1	Petite Sirah	1	FPMS FV C10V8	Larkmead 2:19
D2	Petite Sirah	1	VEN TV MO10V27	Larkmead 2:19
D3	Petite Sirah	2	VEN TV N5V13	Concannon 29:16
D4	Petite Sirah	3	FPMS BKS G9V3	Kunde 7:3
D5	Petite Sirah	3	VEN TV MO10V28	Kunde 7:3
D6	Petite Sirah	3	VEN TV MO10V29	Kunde 7:3
D7	Petite Sirah	4	VEN TV MO10V30	Jackson D18:7
D8	Petite Sirah	4	VEN TV MO10V31	Jackson D18:7
D9	Petite Sirah	5	FPMS FV J5V9	J58V19
D10	Petite Sirah	5	VEN TV MO10V32	J58V19
D11	Petite Sirah	5	VEN TV MO10V33	J58V19
D12	Petite Sirah	895	NCGR WS CD13V3	PI113643, France
D13	Petite Sirah	896	NCGR WS A12V18	PI113643, France
D14	Durif	2	VEN TV MO4V9	Concannon 29:16
D15	Durif	5	VEN TV N7V14	J58V19
D16	Durif	5	VEN TV N7V22	J58V19
D17	Durif	709	NCGR WS A9V44	PI173264, Italy
D18	Durif	710	NCGR WS A9V45	PI173264, Italy
D19	Syrah	1	VEN TV MO19V17	PI391482, France
D20	Syrah	S1	FPMS FV QAV60	PI391482, France
D21	Serine	955	NCGR WS B13V23	Unknown
D22	Pinot noir	S21	FPMS GQ1 4V98	Dijon, France
<b>Montpellier</b>				
F1	Durif	159.10		Aveyron, France
F2	Durif	159.11		Doubs, France
F3	Durif	159.12		Drome, France
F4	Peloursin	174.02		Isere, France
F5	Peloursin	174.04		Isere, France
F6	Peloursin	174.11		Jura, France
F7	Peloursin	174.14		Hautes Alpes, France
F8	Syrah	150.03		Tarn et Garonne, France
F9	Syrah	150.07		Hermitage, France
F10	Syrah	150.13		Cornas, France
F11	Syrah	150.24		Vaucluse, France

<sup>1</sup>The name assigned to each vine prior to this study.

<sup>2</sup>FPMS: Foundation Plant Materials Service; VEN: Tyree Vineyard, Department of Viticulture and Enology; NCGR: National Clonal Germplasm Repository.

VVMD28, VVMD31 [3], VVS2, and VVS4 [12]. One French accession each of Durif, Peloursin, and Syrah were also analyzed at 17 additional loci (Table 4) [3; M. Thomas, personal communication]. Samples from Monterey and Sonoma and from one Napa vineyard were analyzed only at the first four loci listed above. Mendocino samples and samples from the second Napa vineyard were analyzed at eight loci (VVMD5, VVMD6, VVMD7, VMD24, VVMD27, VVMD28, VVMD31, VVMD32).

Polymerase chain reaction amplifications, polyacrylamide gel electrophoresis, and silver staining were performed as described in Bowers *et al.* [2]. Allele sizes were

determined by comparison to known references and each distinct SSR genotype was assigned a letter. Varietal identity was assigned by comparison to the control vines. All samples were analyzed at least twice from separate DNA extractions.

**Parentage analysis:** Likelihood ratios were calculated as in Hagelberg *et al.* [8] as modified by Bowers and Meredith [4].

## Results

**RFLP analysis:** As shown in Tables 2 and 3, the patterns produced by most Davis vines fell into four groups that were designated A, B, C, and D. One vine of Petite Sirah 3 produced an anomalous pattern (E) in 1992, but in 1994 it conformed to pattern A (Table 2). Ambiguous results were obtained for several other vines in 1994. Very few bands were detected for Petite Sirah 2, one vine of Petite Sirah 3, Durif 2, and one vine of Petite Sirah 4. One additional 1A10 band was observed for Serine in 1994 that was not seen in 1992. The French accessions of Durif, Peloursin, and Syrah produced patterns A, B and D, respectively (Table 2).

Both vines from Sonoma vineyard 1 produced a pattern that was identical to that of Peloursin except that it contained one additional 1A10 band (Table 3). All other Sonoma and Monterey vines produced the Durif pattern.

**SSR analysis:** Classifying the French and Davis vines according to their SSR genotypes resulted in the same groups as produced by RFLP analysis (Fig. 1, Table 2). In contrast to the RFLP results, the SSR analyses produced no ambiguous or anomalous results. Patterns A, B, C, and D correspond to Durif, Peloursin, Pinot noir, and Syrah, respectively.

In the commercial vineyards, all the vines that had an appearance typical of the Petite Sirah phenotype were of type A (Durif) or B (Peloursin) (Table 3). Several other patterns were detected for vines that did not have the typical Petite Sirah appearance (data not shown).

SSR allele sizes for Peloursin, Durif, and Syrah are shown in Figure 2 and Table 4.

## Discussion

**Davis vineyards.** We were able to identify all the Petite Sirah accessions in the University of California and National Clonal Germplasm Repository vineyards. Some of the RFLP results were inconclusive, but the SSR method produced clear, reproducible, and unambiguous results for all vines analyzed. SSR analysis, for a number of reasons described elsewhere [2,12], is the most reliable of the presently available DNA typing methods for grapevines.

We conclude that Petite Sirah 1, 3, and 5 are Durif because their DNA profiles at all eight SSR loci at which the Davis accessions were analyzed are identical to those of all three authentic accessions of Durif from France (Fig. 1, Table 2). Vines from both the Department of Viticulture and Enology and Foundation Plant Materials Service were analyzed for each selection. Each

Table 2. DNA profiles obtained for Montpellier and Davis vines with 4 RFLP probes and 8 SSR markers.

Sample no.	Vine- yard label <sup>2</sup>	Acces- sion no.	DNA profile type <sup>1</sup>			Identity
			RFLP 1992	RFLP 1994	SSR	
D1	Petite Sirah	1	— <sup>3</sup>	A	A	Durif
D2	Petite Sirah	1	A	A	A	Durif
D3	Petite Sirah	2	B	? <sup>4</sup>	B	Peloursin
D4	Petite Sirah	3	—	A	A	Durif
D5	Petite Sirah	3	E	A	A	Durif
D6	Petite Sirah	3	A	?	A	Durif
D7	Petite Sirah	4	C	C	C	Pinot noir
D8	Petite Sirah	4	C	?	C	Pinot noir
D9	Petite Sirah	5	—	A	A	Durif
D10	Petite Sirah	5	A	A	A	Durif
D11	Petite Sirah	5	—	A	A	Durif
D12	Petite Sirah	895	A	A	A	Durif
D13	Petite Sirah	896	D	—	D	Syrah
D14	Durif	2	B	?	B	Peloursin
D15	Durif	5	A	A	A	Durif
D16	Durif	5	B	?	B	Peloursin
D17	Durif	709	A	A	A	Durif
D18	Durif	710	B	?	B	Peloursin
D19	Syrah	1	D	D	D	Syrah
D20	Syrah	s1	—	D	D	Syrah
D21	Serine	955	C	?	C	Pinot noir
<b>Controls</b>						
D22	Pinot noir	s21	—	—	C	
F1	Durif	159.10	—	A	A	
F2	Durif	159.11	—	A	A	
F3	Durif	159.12	—	A	A	
F4	Peloursin	174.02	—	B	B	
F5	Peloursin	174.04	—	B	B	
F6	Peloursin	174.11	—	B	B	
F7	Peloursin	174.14	—	B	B	
F8	Syrah	150.03	—	D	D	
F9	Syrah	150.07	—	D	D	
F10	Syrah	150.13	—	D	D	
F11	Syrah	150.24	—	D	D	

<sup>1</sup>Within a column, each letter indicates a different DNA pattern.

<sup>2</sup>The name assigned to each vine prior to this study.

<sup>3</sup>Not analyzed.

<sup>4</sup>Ambiguous pattern.

Table 3. DNA patterns of typical Petite Sirah vines from commercial vineyards with 4 RFLP markers and 4 or 8 SSR markers (see footnote).

Vineyard	Vine	DNA profile type <sup>1</sup>			Identity	Vineyard	Vine	DNA profile type <sup>1</sup>		
		1994 RFLP	SSR					1994 RFLP	SSR	
<b>Mendocino</b>					<b>Mendocino (cont'd)</b>					
1	1	— <sup>2</sup>	A	Durif	16	1	—	A	Durif	
	2	—	A	Durif		2	—	A	Durif	
	3	—	B	Peloursin		3	—	A	Durif	
	4	—	A	Durif	17	1	—	A	Durif	
2	1	—	A	Durif		2	—	A	Durif	
	2	—	A	Durif		3	—	A	Durif	
3	1	—	A	Durif	<b>Monterey</b>					
	2	—	A	Durif	1	1	A	—	Durif	
4	1	—	A	Durif		2	A	—	Durif	
	2	—	A	Durif	<b>Napa</b>					
	3	—	A	Durif	1	1	—	A <sup>3</sup>	Durif	
5	1	—	A	Durif		2	—	A <sup>3</sup>	Durif	
	2	—	A	Durif		2	—	A <sup>3</sup>	Durif	
6	1	—	A	Durif	<b>Sonoma</b>					
	2	—	A	Durif	1	1	? <sup>4</sup>	B <sup>3</sup>	Peloursin	
7	1	—	A	Durif		2	?	B <sup>3</sup>	Peloursin	
	2	—	B	Peloursin	2	1	A	A <sup>3</sup>	Durif	
8	1	—	A	Durif		2	A	A <sup>3</sup>	Durif	
	2	—	A	Durif	3	1	A	A <sup>3</sup>	Durif	
9	1	—	A	Durif		2	A	A <sup>3</sup>	Durif	
	2	—	A	Durif	4	1	A	A <sup>3</sup>	Durif	
10	1	—	A	Durif		2	A	A <sup>3</sup>	Durif	
11	1	—	A	Durif		3	A	A <sup>3</sup>	Durif	
	2	—	A	Durif	5	1	A	A <sup>3</sup>	Durif	
12	1	—	A	Durif		2	A	A <sup>3</sup>	Durif	
13	1	—	A	Durif		3	A	A <sup>3</sup>	Durif	
14	1	—	A	Durif	6	1	A	—	Durif	
15	1	—	A	Durif						
	2	—	A	Durif						

<sup>1</sup>Within a column, each letter indicates a different DNA pattern.

<sup>2</sup>Not analyzed.

<sup>3</sup>Analyzed at 4 SSR loci. All others analyzed at 8 SSR loci as described in **Materials and Methods**.

<sup>4</sup>Ambiguous pattern.

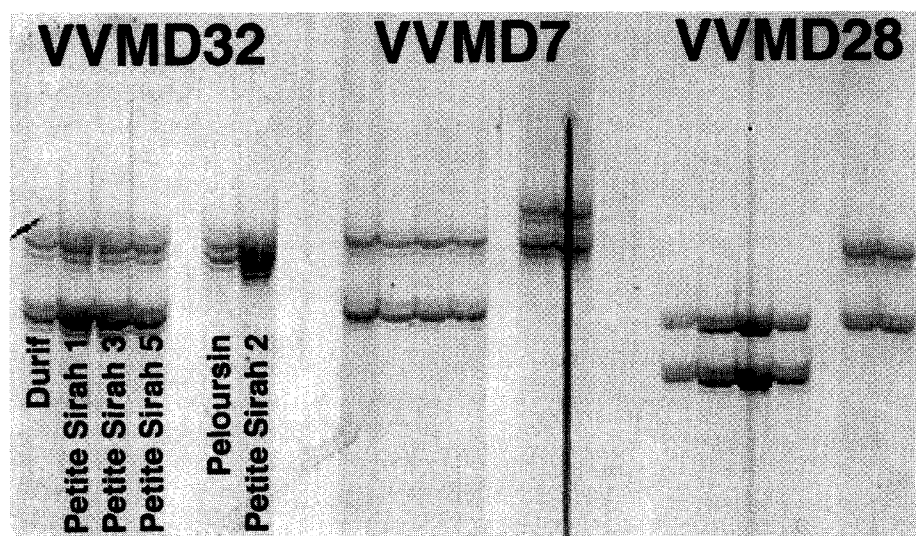


Fig. 1. Comparison of Petite Sirah 1, 2, 3, and 5 from UC Davis to reference vines of Durif and Peloursin from Montpellier at 3 SSR loci (VVMD32, VVMD7, VVMD28). The arrangement of the varieties for VVMD7 and VVMD28 is as indicated for VVMD32. For each SSR locus, Petite Sirah 1, 3, and 5 have the same alleles as Durif and Petite Sirah 2 has the same alleles as Peloursin.

of these three selections can be traced back to an old California vineyard in a different county. The probability that the Durif SSR genotype could occur by chance in another variety can be estimated from the frequencies of the individual alleles in the general population of *Vitis vinifera* cultivars. Based on allele frequencies obtained from a survey of 51 cultivars [unpublished results], the probability that Petite Sirah 1, 3, and 5 are not Durif is approximately  $1.3 \times 10^{-11}$  or less than 1 in 70 billion.

Petite Sirah 2 is identical to all four French accessions of Peloursin. This selection originated in an old California vineyard and is identified in some records as Durif 2. This misnomer may have arisen during the 1970s, when the notion that Petite Sirah was Durif became widespread

and some people began to refer to all Petite Sirah as Durif. Durif 2 is also identical to Peloursin. The current planting of Durif 2 in the Tyree Vineyard can be traced back to the same source vine as Petite Sirah 2 (Table 1). Both names are used in various records of this accession. The probability that Petite Sirah 2 and Durif 2 are not Peloursin is approximately  $2.1 \times 10^{-12}$  or less than 1 in 400 billion.

Petite Sirah 4 is clearly a misidentified accession. Both vines analyzed have DNA profiles identical to that of the Pinot noir control and, in fact, were identified as Pinot types by J.-M. Boursiquot on the basis of a visual inspection before the DNA analysis was performed [personal communication].

Petite Sirah 895, in the Germplasm Repository, is also identical to Durif and was introduced in 1936 from France. The name Durif appears on some records associated with this accession. Petite Sirah 896 is identical to Syrah even though importation records indicate that it originated in the same 1936 introduction as 895. Either the original introduction was a mixture or a planting

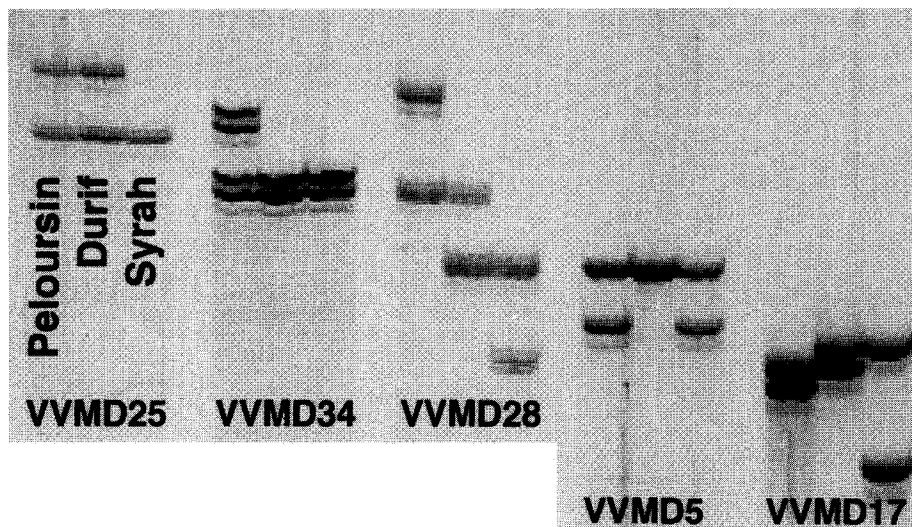


Fig. 2. Inheritance of SSR alleles by Durif at 5 SSR loci. Within each group of three lanes, Peloursin is on the left, Durif is in the center and Syrah is on the right. For each locus, Durif shares one allele with Peloursin and one with Syrah.

error has since occurred.

Durif 5 includes both Durif and Peloursin vines. The current planting of Durif 5 in Tyree Vineyard can be traced to the same source vine as Petite Sirah 5. However, one of the two Durif 5 vines tested is identical to Durif but the other, in the same vineyard row, is identical to Peloursin.

Records associated with Durif 709 and 710, in the Germplasm Repository, indicate that they were introduced from Italy. Although records suggest that they were both part of a single accession, they are different genotypes. Accession 709 is identical to Durif and 710 is identical to Peloursin.

Both Davis accessions of Syrah that were analyzed are identical to all four French Syrah accessions. Serine is a name that has been used for Syrah in France [7,13], but the Repository accession labeled as Serine 955 is actually Pinot noir. The origin of this accession is unknown but is presumably an old California vineyard, where it may have been known as Serine.

In several cases above (*e.g.*, Petite Sirah 895 and 896, Durif 5, Durif 709 and 710) discrepancies could be the result of planting or labeling errors. Such errors would not be surprising considering that most of these accessions have been held for many decades by the Department of Viticulture and Enology, during which time they have been repropagated and replanted several times. The Germplasm Repository accessions of Petite Sirah, Durif, and Serine were initially propagated from

Table 4. Comparison of Peloursin, Durif, and Syrah alleles at 25 SSR loci.

Locus	Allele size (bp)					
	Peloursin		Cultivar		Syrah	
			Durif			
VVMD5	226	232	232	232	226	232
VVMD6	205	214	205	214	205	214
VVMD7	251	257	239	251	239	239
VVMD8	141	143	141	143	141	143
VVMD14	222	232	222	232	222	241
VVMD16	168	168	168	168	166	168
VVMD17	220	222	222	224	212	224
VVMD21	249	249	249	266	249	266
VVMD23	177	177	177	177	177	177
VVMD24	210	214	210	214	210	216
VVMD25	245	253	245	253	245	245
VVMD26	249	251	251	251	251	255
VVMD27	179	189	179	191	189	191
VVMD28	239	251	231	239	221	231
VVMD31	210	216	210	216	212	216
VVMD32	251	253	241	253	241	273
VVMD34	240	248	240	240	240	240
VVMD36	264	297	254	297	254	295
VVS1	181	190	181	181	181	181
VVS2	133	151	133	151	133	133
VVS4	167	175	168	175	168	173
VVS16	284	284	278	284	263	278
VVS19	163	192	186	192	186	205
VVS29	171	171	171	171	171	179
VH43	210	210	210	210	210	213

accessions originally held by the Department of Viticulture and Enology and since then have also been repropagated.

Most of the Davis Petite Sirah accessions that were analyzed were originally obtained from old California vineyards and thus likely represent at least some of the varietal diversity that existed at that time. Because many California vineyards were and still are propagated from neighboring vineyards, it is likely that much of that diversity still exists today. Vineyards propagated from nursery material originating from Foundation Plant Materials Service at UC Davis may be less diverse. Currently, only Petite Sirah 3 is registered in the California Clean Stock Program, but in the past Petite Sirah 1 and 5 were also registered [S. Nelson-Kluk, personal communication]. Since Petite Sirah 1, 3, and 5 are all now known to be Durif, any Petite Sirah vineyards planted with certified material are probably Durif. At one time, Petite Sirah 1, 2, 3, 4, and 5 were all planted in the Foundation Plant Materials Service vineyard. Although Petite Sirah 2 and Petite Sirah 4 have never been registered, it is possible that propagules from these FPMS selections may have been distributed at one time.

**Commercial vineyards.** We surveyed 26 commercial Petite Sirah vineyards in four California counties, analyzing a total of 53 vines with a typical Petite Sirah appearance (one to four vines from each vineyard). Most of these vines were Durif, but four vines (from three vineyards) were Peloursin. At least two of these three vineyards contain both Durif and Peloursin. Although we detected Peloursin only in Sonoma and Mendocino counties, it may also be present in Napa and Monterey counties but not have been detected because of the small number of samples obtained from these counties.

Durif and Peloursin differ only slightly in appearance [7] and even an expert ampelographer may have difficulty distinguishing them. The teeth on the leaves of Durif are described as straight-sided, compared to the more convex teeth of Peloursin. Peloursin leaves are described as more deeply lobed than those of Durif. Peloursin leaves are described as hairless below compared to the slightly tomentose leaves of Durif [7]. However, our experience in commercial vineyards containing both varieties is that these distinctions are rarely evident.

Many old Petite Sirah vineyards also contain other varieties, but these are easily distinguished from typical Petite Sirah by their appearance. Among the varieties detected in Petite Sirah vineyards in this study were Aubun, Barbera, Carignane, Colombard, Grenache, Syrah, Valdiguié, and Zinfandel (results not shown).

**The origin of Durif:** Durif is described as a seedling or selection of Peloursin produced in 1880 by Dr. Durif in France [7]. Our data is consistent with the former and excludes the latter possibility. At each of 25 SSR loci analyzed, Durif shares at least one allele with Peloursin, as would be expected of a parent-progeny relationship but the two share both alleles at only 14 of the loci, almost impossible if Durif were a clonal selec-

tion of Peloursin (Table 4). Clones within Pinot noir, for example, are identical at all or nearly all SSR loci examined [Bowers and Meredith, unpublished results]. Thus, the SSR data are consistent with Peloursin being the maternal parent of Durif.

Because Durif has alleles not found in Peloursin (Table 4), it cannot be a self-pollinated seedling of Peloursin but must have resulted from the pollination of Peloursin by another cultivar. On the basis of the SSR data presented here, we conclude that the pollen parent of Durif is Syrah. As shown in Figure 1 and Table 4, at each of the 25 SSR loci analyzed, the Durif alleles can be accounted for by the contribution of one allele each from Peloursin and Syrah. (We discount the possibility that Durif is a parent of either Syrah or Peloursin because the relatively young age of Durif is well-documented and the other two varieties are known to be much older.)

Allele frequencies were used to calculate the relative likelihood that Peloursin and Syrah are the parents of Durif compared to other possible parents (as done in Bowers and Meredith [4] for the parentage of Cabernet Sauvignon). Based on allele frequency estimates obtained from a survey of 48 cultivars, the Peloursin  $\times$  Syrah parentage is  $2.73 \times 10^{13}$  times more likely than two other random varieties. If Peloursin is the maternal parent of Durif, Syrah is  $1.74 \times 10^8$  times more likely to be the pollen parent than another random variety and 196 times more likely than a close relative of Syrah (*i.e.*, sibling, parent or seedling). If 95% upper confidence limits of the allele frequencies are used in order to compensate for the relative small number of varieties on which they are based, then the three likelihood numbers drop to  $8.16 \times 10^7$ , 252 398, and 23.9, respectively.

We have demonstrated that most Petite Sirah vines in California are Durif, but that some are Peloursin. We have also provided strong genetic evidence that Durif is the progeny of Peloursin and Syrah. This work emphasizes the importance of using authentic references when identifying grape varieties by DNA profiling methods since, as in human DNA profiling, identification relies entirely on comparison to known references. For example, had we relied upon the Davis Durif 2 accession which we now know is actually Peloursin, as the reference for Durif, we might have concluded, incorrectly, that Petite Sirah 1, 3, 5, and 895 are not Durif. Thus, great caution should be exercised in choosing reference vines for variety identification. In New World regions in particular, we recommend that reference vines be chosen from recent introductions having a well-documented history or from well-established European collections in the country most closely associated with the cultivar.

To minimize error, we used as references at least three accessions from the Montpellier collection for each variety, chosen for the geographic diversity of their original vineyard sources in France. Not only did this serve as a control to detect planting, labeling, shipping, and laboratory errors, but it also enabled us to detect genetic heterogeneity that might exist within the cultivars in France. For each cultivar — Durif, Peloursin,

and Syrah— the French accessions were found to be completely uniform.

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