Analysis of the pest risk from Grapevine flavescence dorée phytoplasma to Austrian viticulture

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In 2004, *Scaphoideus titanus*, vector of Grapevine flavescence dorée phytoplasma, was first recorded in Austrian vineyards. The absence of the phytoplasma in 2004-06 was confirmed by molecular analyses of grapevine and vector samples. To estimate the risk to Austrian viticulture a Pest Risk Analysis (PRA) was conducted, following the EPPO decision support scheme. The highest risk of introduction arises from the extensive trade in rootstocks and, especially for vineyards located along traffic routes and waterways, from the passive or active spread of the vector. Climate will not limit the establishment of the vector in the large northern Austrian vine-growing regions of Niederösterreich and Burgenland. At present the probability that the disease and vector become associated is restricted to parts of South Styria. Plant protection practice cannot prevent the establishment and spread of vector populations, especially in sustainable production systems, which forms more than 70% of the total Austrian viticulture area. The possibility for containment or even eradication is given, but requires an early recognition of the vector and disease and the immediate initiation of measures. Otherwise, losses to vine growers, follow-up costs for eradication and additional efforts in the production of plants would be substantial. Following the assessment, legal measures and recommendations to prevent disease entry and to minimise impacts of established vector populations are considered.

Introduction

Grapevine flavescence dorée phytoplasma causes an epidemic disease in *Vitis vinifera*. It is listed in Annex IIA2 EU2000/29 and is an A2 quarantine pest in the EPPO region. The phytoplasma is transmitted by the nearctic leafhopper *Scaphoideus titanus*. In recent decades the disease has spread actively in many parts of Europe. The vector is expanding its range to the north: in 2004 *S. titanus* was found in Styria (Austria) in vineyards close to the Slovenian border, where it is now at the north-eastern border of its range. Flavescence dorée is currently not present in Austria, neither in vector populations nor in *Vitis* plants. A Pest Risk Analysis was conducted to estimate the risk to Austrian viticulture in the different growing regions (which range from latitude 46°39′ (in South Styria to 48°47′ in Niederösterreich).

Materials and methods

Pest risk assessment

The pest risk assessment is conducted by following the EPPO decision support scheme for quarantine pests in which questions concerning the potential of entry, establishment, spread and economic damage within the endangered area are answered. The answers are scored by using a five-point scale, in which low scores are used for 'unlikely' or events of 'low impact' while high scores are used for 'very likely' or events of 'high impact'.

Judgement is given by taking into account data from trade statistics, published sources, the Internet and personal communications. Climatic data from different climatic stations are compared. For both flavescence dorée and *Scaphoideus titanus* monitoring data for 2004, 2005 and 2006 were available, which had been collected within the research project: 'Studies on the importance, geographical distribution and epidemiology of phytoplasmic diseases in Austrian viticulture' at the Institute for Plant Health, AGES, Austria.

The assessment is completed by conclusions on the probability of entry and establishment and on the economic impact of introduction. The different pathways which make entry most likely as well as the most endangered parts of the PRA-area are indicated. A survey of the risk assessment using the EPPO pest risk assessment scheme is given in Table 2. In the main text the essential parts of the assessment are further discussed.

Pest risk management options

Based on the results of the assessment, management options for the currently most likely disease and/or vector entry pathways are examined.

Results of the pest risk assessment

Two relevant pathways need to be taken into consideration:

(1) International trade with rootstocks, scions and grafted vine with countries in which the disease occurs

(2) Active or passive spread of the vector.

Entry by trade

Current situation in Austria concerning the occurrence of flavescence dorée

In Austrian vineyards a survey of flavescence dorée was conducted during 2004, 2005 and 2006. Molecular analyses (PCR-RFLP) of 111 grapevine and 492 *Scaphoideus titanus* samples confirmed that flavescence dorée is not present in Austria.

Occurrence of flavescence dorée in Europe

Flavescence dorée is widespread in many vine-growing regions of *France*, where it is actively spreading in Aquitaine, Languedoc-Roussillon and Midi-Pyrénées, stable in Corsica, Jura, Rhône-Alpes, and contained in Bourgogne, Champagne, Centre and Pays de Loire (Descoins, 1995). Recent outbreaks were discovered in Savoie in 2000 and 2001 (Herlement, 2002; Boudon-Padieu, 2003), in the south of the Drome department on the border between the regions Rhone Alpes and Provence-Alpes-Cote d'Azur in 2001 (Herlemont, 2002) and in Moissac (Tarn-et-Garonne), Vaucluse, Gironde and Charentes in 2003 (Herlemont, 2003).

Flavescence dorée is widespread in most of the northern regions of *Italy*. Recently, severe outbreaks were observed in Piemonte (Gotta & Morone, 2001), Lombardy (Belli *et al*., 2000) and Veneto (Martini *et al*., 1999; Belli *et al*., 1997; Sancassani *et al*., 1997). The disease is expanding in Liguria and Emilia-Romagna (Credi *et al*., 2001; Cavallini *et al*., 2003) and is found in parts of Trentino-Alto Adige (Osler & Refatti, 2002) and Tuscany (Bertaccini *et al*., 2003). 65% of Italian nursery production is in Friuli-Venezia Giulia (Frausin, 2000), the region close to the Austrian border. Flavescence dorée has occurred there since the 1980s, 2000 and 2001, mainly in parts of the province Pordenone (Frausin, 2002). Flavescence dorée was not detected in southern regions of Italy.

In *Serbia* flavescence dorée was first confirmed in 2002 (Duduk *et al*., 2003). A survey indicated that the disease is widespread in the region of Aleksandrovac and in some parts of the Nis region (Anonymous, 2005). In 2005 two new outbreaks in Velika Drenova and Grdelica were recorded (Anonymous, 2005).

In *Spain* flavescence dorée was found for the first time in 1996, in the region of Ampudan (Cataluña), near the French border (OEPP/EPPO, 1997). The most important disease foci are in Agullana and in the area between Masarac and St Climent Sescebes, for which the total affected area equals 23 ha (Batlle *et al*., 2000; Rahola *et al*., 1997). In 2001 the 1996 outbreak was considered to be practically eradicated (OEPP/EPPO, 2001). In 2004 the phytoplasma was found in 22 plants from three sites of the region (OEPP/EPPO, 2005a). In other vine-growing regions the disease has not been detected (Espacio *et al*., 2001; Torres *et al*., 2003).

In *Switzerland* flavescence dorée was first detected in 2004 in the Mendrisiotto region near Lake Lugano (Ticino) close to the Italian border (Stäubli, 2005; Gugerli, 2005).

In *Portugal* the disease was only found in infested vectors in the north of the country (DeSousa *et al*., 2003).

Volume of trade

In recent years restructuring measures were promoted by the EU, including set-aside of vineyards as well as clearing and conversion from white to red cultivars (Austrian Federal Ministry of Agriculture, Forestry, Environment & Water Management, 2004). These measures will raise the red wine production area by 3400 ha (Austrian Federal Ministry of Agriculture, Forestry, Environment & Water Management, 2004) and led to an increased demand for planting material. Since the domestic production of rootstocks cannot meet the demand, Austrian viticulture depends on imports of rootstocks. Trade in scions is of minor importance.

Statistical data (summarized in Table 1) indicate that a considerable amount of planting material is imported into Austria from countries in which flavescence dorée occurs. The data distinguish between consignments of rootstocks and scions intended for grafting and grafted vine with roots. The amount of planting material that can be produced from the material imported between 2003 and 2005 from France and Italy, where flavescence dorée is widespread, can be estimated as providing a potential planting area of at least 4000 ha. Trade with Spanish nurseries is less extensive. Moreover, of the 603 nurseries registered in Spain (Spanish Ministry of Agriculture, Fisheries & Food, 2005) only two are situated within a radius of 50 km of focal points of flavescence dorée. The pathway from Serbia is closed due to legal requirements of EC Directive 2000/29. Trade in planting material of *Vitis vinifera* with Switzerland is of minor importance, and no trade with Portugal has been undertaken from 2003 to 2005.

Import data indicate that the last EU-expansion in 2005 marked the beginning of an extensive trade with the new EU accession countries. In 2007 Romania and Bulgaria have joined the EU. Due to their proximity to infested zones in Serbia, one (unconfirmed) report of flavescence dorée in the 1970s (Rafaila & Costache, 1970) in Romania and the expected interest of Austrian nurseries in trade, the accession of Romania and Bulgaria could be of major concern.

Phytosanitary measures

In Annex IV/A2 of the EC Directive 2000/29 requirements for the movement of *Vitis* plants originating in the community are defined, i.e. an official statement that no symptoms of flavescence dorée have been observed on the mother stock plants at the place of production since the beginning of the last two complete cycles of vegetation. In all countries in which flavescence dorée occurs, both disease and vector are subject to official control. Eradication programmes, including the

Table 1 Import volume of planting material of *Vitis vinifera* in 2003, 2004 and 2005 (Statistic Austria, 2006). (a) Rootstocks (Cuttings for grafting without roots) and scions (Statistic Austria, 2006)

	2003			2004			2005		
Country of origin	Value EUR	Plants (estimated)*	Area ha	Value EUR	Plants (estimated)*	Area ha	Value EUR	Plants (estimated)*	Area ha
Italy	158 009	1717 489	513	157 657	1713 663	512	111 922	1216 543	363
France	107 315	1166 467	348	290 494	3157 543	943	213 188	2317 261	692
Spain	49 700	540 217	161	35 872	389 913	116	/	/	/
Netherlands	46 045	500 489	149	37 053	402 750	120	5472	59 478	18
Germany	21 447	233 120	70	146 028	1587 261	474	24 755	269 076	80
Hungary	/	/	/	/	/	/	456 261	4959 359	1480

*Assumptions for estimations:
1. Market price of 1 bundle = 100 cuttings: 23 EUR (price the farmer pays).
2. Profit margin (importer/nursery): 100% (results in a price for the importer of 11.50 EUR.
3. Length of one cutting: 1 m; number of rootstocks that can be gained from one cutting: 3 (approximately 33 cm each).
4. Yield (depending on losses in multiplication, nursery, poor quality): 50%.
5. Planting density: 3350 plants per ha.

Table 1 (b) Grafted vine with roots (Statistic Austria, 2006)

	2003			2004			2005		
Country of origin	Value EUR	Plants (estimated)*	Area ha	Value EUR	Plants (estimated)*	Area ha	Value EUR	Plants (estimated)*	Area ha
Italy	140 429	140 429	42	94 355	94 355	28	100 641	100 641	30
France	712 225	712 225	213	458 470	458 470	137	617 245	617 245	184
Spain	/	/	/	/	/	/	10 637	10 637	3
Netherlands	/	/	/	/	/	/	1476	1476	0
Germany	527 560	527 560	157	340 713	340 713	102	235 758	235 758	70
Switzerland	/	/	/	/	/	/	6668	6668	2
Hungary	/	/	/	66 343	66 343	20	633 872	633 872	189
Czech Rep.	/	/	/	/	/	/	4657	4657	1
Slovakia	/	/	/	/	/	/	301 982	301 982	90
Slovenia	/	/	/	/	/	/	558 877	558 877	167
Cyprus	/	/	/	/	/	/	88 875	88 875	27

*Assumptions for estimations:
1. Market price of a grafted vine: 2 EUR.
2. Profit margin (importer/nursery): 100% (price for the importer: 1 EUR).
3. Planting density: 3350 plants per ha.

elimination of diseased plants and insecticide applications to control the vector are mandatory (de la Rocque, 2003; Osler & Refatti, 2002; Zandigiacomo & Frausin, 1998; Spanish Ministry of Agriculture, Fisheries & Food, 2005; Rahola *et al*., 1997). Certification schemes for propagation material have been designed and came into force in order to reduce the risk of dissemination of flavescence dorée (OEPP/EPPO, 1994; de la Rocque, 2003; Marzorati & Pajoro, 2006). Various trials have confirmed the efficiency of hot water treatments to eliminate flavescence dorée from infested planting material (Caudwell *et al*., 1997; Tassart *et al*., 2003; Crocker *et al*., 2003). Careful application of this method has no detrimental effect on growth of the plants (Boudon-Padieu, 2003), yet it has still not achieved acceptance in nursery production (Maixner & Holz, 2003).

Difficulties in inspection arise through the fact that field symptoms of the disease are not specific and might be confused with symptoms caused by other pathogens, especially Grapevine bois noir and Grapevine Leaf Roll-associated closteroviruses. Moreover, most grapevine rootstocks are potential symptomless carriers of flavescence dorée (Caudwell *et al*., 1994). Such rootstocks have been shown to be responsible for dissemination of flavescence dorée in France (Boudon-Padieu, 1999). Despite the requirements laid down in EC-directive 2000/29 and the eradication measures applied in the different countries, flavescence dorée has been intercepted in *Vitis vinifera* plants for planting, originating in France and shipped to Germany (OEPP/EPPO, 2004). Furthermore several outbreaks of flavescence dorée have been recorded in Europe in recent

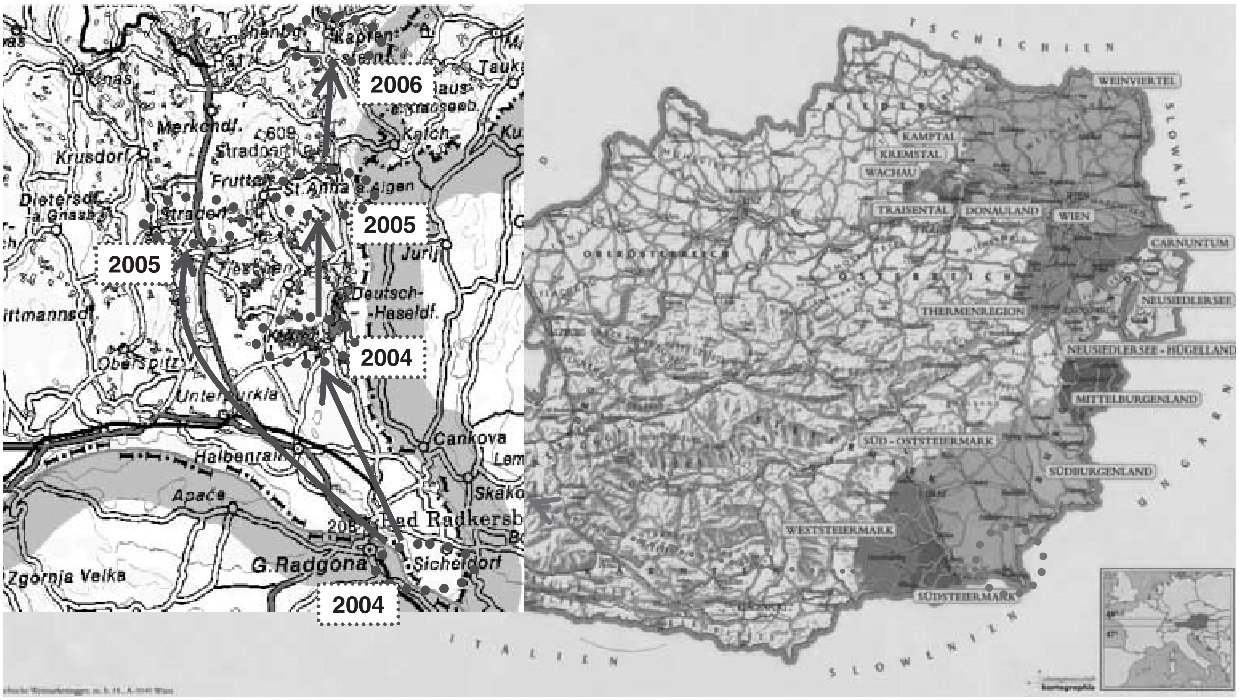

Fig. 1 Map of Austrian vine growing regions (Österr. Weinmarketing ges.m.b.H, 1999) and records of *Scaphoideus titanus* in Austria. Wine production is restricted to the eastern part of the country (highlighted regions). The area where a population of *Scaphoidues titanus* is established is marked by a dotted circle. The detailed map shows the spread of *Scaphoideus titanus* from the first findings in Sicheldorf in 2004 to the north in 2005 and 2006.

years (see above), indicating that phytosanitary measures used in the production of planting material cannot always prevent the unintended dissemination of flavescence dorée.

Entry by means of active or passive spread of the vector

Occurrence of Scaphoideus titanus in Europe

The vector *S. titanus* was introduced to Europe in the 1950s from Northern America. Since then it has spread actively and extended the northern and southern border of its range. It is present wherever the disease is established. Moreover, the distribution of the vector exceeds the distribution of the phytoplasma. Its appearance in a region was often a precursor of disease outbreaks. Recently *S. titanus* has spread southwards in Italy: it was detected in the provinces of La Spezia, Massa Carrara and Lucca (Mazzoni *et al*., 2001), the regions of Tuscany (Santini & Lucchi, 1998); Umbria (Santinelli *et al*., 2003); Basilicata, Apulia and Calabria (Viggiani, 2004) and Campania (Danise *et al*., 2005). In Val d'Aosta in northern Italy there is a stable population of *S. titanus*, although flavescence dorée has never been detected in surveys (OEPP/EPPO, 2003; OEPP/EPPO, 2005b). *S. titanus* was identified in northern Portugal (Quartau *et al*., 2001) and it has been contained in Switzerland to around Lake Geneva (Clerc *et al*., 1997; Linder, personal communication). In the eastern parts of Europe it is widespread in Slovenia in the vineyards of the Primorska region (Petrovic *et al*., 2003; Seljak & Petrovic, 2001) and in most parts of central and southern Serbia (Magud & Tosevski, 2004). In Croatia and Hungary the occurrence of both vector and disease are not confirmed, though grapevine yellow symptoms are widespread (Kölber *et al*., 2003; Curkovic-Perica *et al*., 2003). In Austria it first appeared in Southern Styria in 2004 in Sicheldorf and Klöch (Zeisner, 2005). In 2005 and 2006 it was found in five of the region's villages (Fig. 1).

All areas in which the vector is present are highly endangered, because any introduction of grapevine planting material latently contaminated with the phytoplasma, might result in serious epidemics of the disease (Smith *et al*., 1997). This is due to the highly specialized and efficient transmission by the vector.

Possible pathways for active or passive spread of the vector

The vineyards in Slovenia's border region are situated in close proximity to the ones around Bad Radkersburg in Southern Styria. Passive spread by north-westerly winds along the valley of the river 'Mur' is assumed to be the cause of the appearance of the vector in Southern Styria. This is supported by the fact that hundreds of specimens of *S. titanus* were caught in yellow sticky traps at observation plots close to the river 'Mur', while further inland the abundance of the vector is lower. Monitoring data showed that the vector is also able to fly to vineyards which are several kilometres away from infested sites. Likewise, on the basis of the spatial distribution of flavescence dorée-affected plots in Catalunia, Spain, Torres *et al*. (2003) suggested that the Tramontana wind – a dry cool northerly wind in the

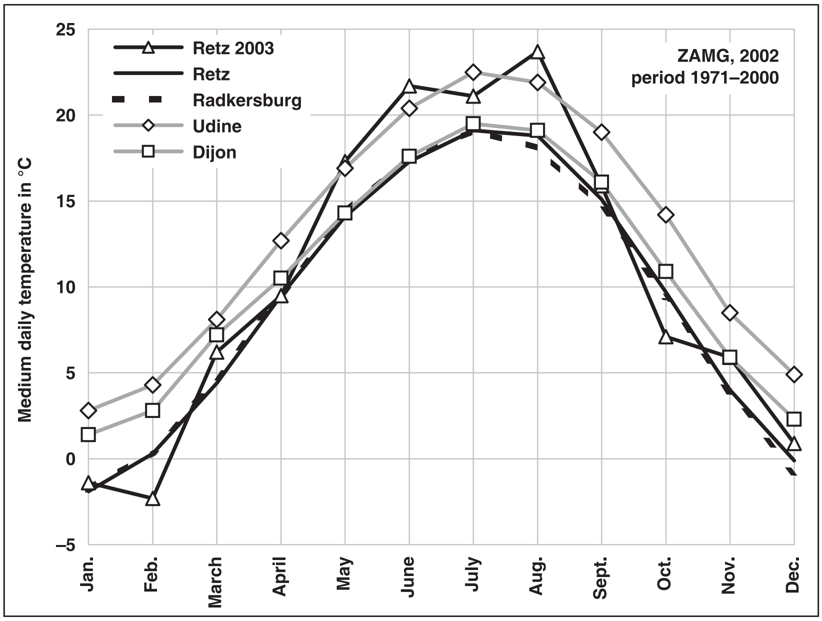

Fig. 2 Medium daily temperature of Radkersburg (Latitute: 46°41′N, Longitude: 15°59′E) and Retz (48°46′N, 15°57′E) compared to vine growing regions in Italy (Udine, Friuli-Venezia Giulia, 46°04′N, 13°14′E) and France (Dijon, Bourgogne 47°16′N, 05°06′E) and compared to Retz in 2003, a year with a warm and dry summer.

Mediterranean – was helping *S. titanus* spread from infested zones to healthy plots. Southern Styria is a high risk entry point for the disease.

The Italian region Friuli-Venezia-Giulia borders the Austrian region of Carinthia. In Friuli-Venezia-Giulia the disease and its vector has been established since the 1980s (Borgo, 1989). The Alps form a natural barrier for the active spread of leafhoppers; moreover Carinthia has only a few hectares of viticulture. Nevertheless these vineyards are located in sites with favourable climatic conditions, many of them along the main traffic route which connects Friuli-Venezia-Giulia with Carinthia and Styria. The spread of the vector along highways has been reported from Trentino, Italy (Maixner, 2005), thus unintended long distance dispersal along the railway and highway cannot be ruled out completely. Carinthia seems to be a medium risk entry point.

Establishment and spread

The principal and economically most important host of flavescence dorée is *Vitis vinifera* (Smith *et al*., 1997), though *Vitis riparia* can be infected naturally (Maixner *et al*., 1993). In a recent survey 40 different species of wild herbaceous and woody plants were collected in underbrush close to a flavescence dorée-infested vineyard. Only samples of *Clematis vitalba* were found to be infected with flavescence dorée, but showing no symptoms (Angelini *et al*., 2004). *Clematis* sp. are widespread on wasteland and waysides within the PRA-area.

The viticulture area in Austria is 51 970 ha (Austrian Federal Ministry of Agriculture, Forestry, Environment & Water Management, 2005). Vines are produced mainly in the eastern part of the country (Fig. 1). The area extends from Southern Styria near to the Slovenian border (Radkersburg, latitude 46°41′N) up to the large vine-growing regions in the north (Retz, lat. 48°46′N).

Similarity of climatic conditions

S. titanus, the principal vector of flavescence dorée, is a monophagous species. Little is known about *S. titanus* apart from its biology and disease transmission (Lessio & Alma, 2004), especially concerning its temperature thresholds. *S. titanus* has established populations in different environmental zones in Europe (Metzger *et al*., 2005), demonstrating its ability to adapt to different climates. In 2004 *S. titanus* was detected in Southern Styria for the first time, a location which is at the north-eastern border of its current spread. In Fig. 2 the medium daily temperature of Bad Radkersburg (South Styria) is compared with Retz (Lower Austria) and two regions in France and Italy where the vector has formed stable populations. The progression of the temperature in the Austrian locations is almost identical. It is 2.8–4.5°C lower than in the Mediterranean vine growing region of Friuli (Udine). Dijon (Bourgogne) is influenced by an Atlantic climate: while the winter temperatures are 1.9–3.3°C warmer, the temperatures during the growing season are similar to the Austrian sites. In the warm summer of 2003 the temperature in Retz drew near to those in Udine and was higher than the average temperature in Dijon/Burgundy. Lessio & Alma (2004) ascertained that the activity of the vector is higher during night and correlates with daily minimum temperatures. In Fig. 3, the daily minimum temperatures (May–October) of different European locations in which *Scaphoideus titanus* is established, are compared to Austrian sites. While values of Radkersburg and Retz are again almost identical and comparable to those of Maribor, and Dijon, the minimum temperature of Neusiedl is 0.6–1.5°C higher, indicating that the microclimate of the vine growing area around Lake Neusiedl could be especially favourable for an establishment of flavescence dorée.

Concerning the similarity of climatic conditions it can be concluded that the winters in the Austrian wine regions are cold

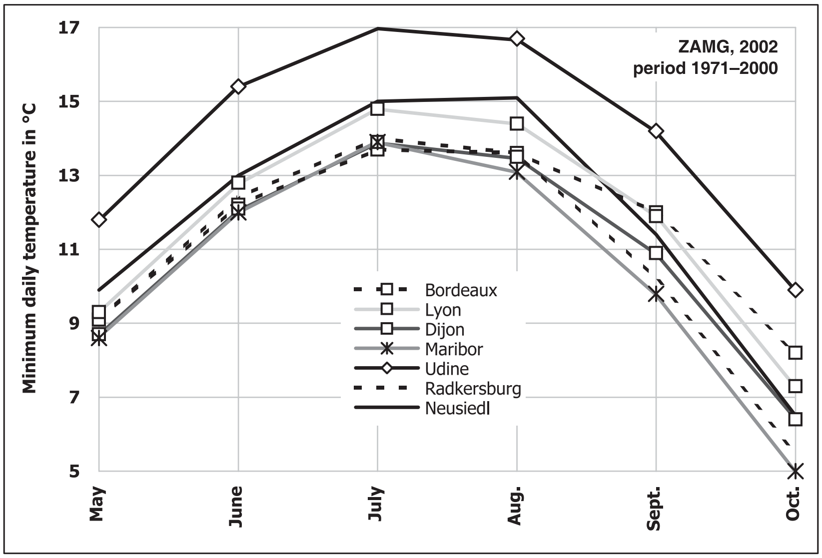

Fig. 3 Minimum daily temperature of Radkersburg (46°41′N, 15°59′E) and Neusiedl (47°57′N, 16°51′E) compared to vine growing regions in Italy (Udine, Friuli-Venezia Giulia, 46°04′N, 13°14′E), France (Dijon, Bourgogne 47°16′N, 05°06′E; Lyon, Rhone-Alpes, 45°43′N, 04°55′E and Bordeaux, Aquitaine, 44°50′N, 00°43′W) and Slovenia (Maribor 46°32′N, 15°39′E).

enough to break diapause of eggs and the summers are most likely warm enough to complete the life cycle and establish stable population. It is assumed that the vector can establish in the different Austrian vine-growing regions especially in consideration of:

- the fact that in Austria the vineyards are commonly located on slopes or along rivers. South-facing slopes in particular receive more sunshine and are characterized by a warmer microclimate; moreover cold air flows down and away, so minimum temperatures are also likely to be higher. This increases the risk of establishment of vector populations
- the global warming due to climate change. The range for the increase of the global mean temperature of the different SRES-scenarios published by the Intergovernmental Panel on Climate Change (IPCC) is +1.4 to +5.8°C, with a greater relative warming at high latitudes (Cubasch *et al*., 2001).

Susceptibility of varieties

Grapevine cultivars play an important role in influencing the proportion of infected leafhoppers in the vineyards and therefore influence the rate of disease progress (Bressan *et al*., 2005). The susceptibility of grapevine varieties to flavescence dorée varies strongly. In Italy two molecularly distinguishable types of flavescence dorée appeared to have different transmission efficiencies and variety preferences (Mori *et al*., 2002; Angelini *et al*., 2001; Bertaccini *et al*., 2000; Martini *et al*., 1999). The cultivars Chardonnay Blanc, Pinot Noir, Pinot Gris, Cabernet Franc, Cabernet Sauvignon, Barbera, Sangiovese, Soave, Prosecco are susceptible (Belli *et al*., 2000; Vercesi & Scattini, 2000, Pavan *et al*., 1997; ENTAV, 1993), while other varieties – like Merlot, Sauvignon Blanc and Syrah seem to be more resistant (Belli *et al*., 2000; ENTAV, 1993). Several varieties of regional importance and essential for the production of unique specialities are extremely susceptible (Sancassani & Posenato, 1995; Pavan *et al*., 1997). In Serbia, as well as some local varieties, Riesling and Italian Riesling (i.e. 'Welschriesling') were also affected (Kuzmanovic *et al*., 2003); Vercesi & Scattini (2000) found 'Italian Riesling' to be least affected.

Husbandry measures in Austria

In Austria the sustainable production area is of a significant size. In 2004 the area on which vine is produced within Integrated Production (IP) programmes is 36 700 ha, which equals 70.6% of the total viticulture area; organic production of grapes takes up 1130 ha, equalling 2.2% of the total viticulture area in Austria (Agrarmarkt Austria, personal communication).

Since the use of broad spectrum insecticides (pyrethroids, organophosphates and carbamates) are restricted in IP-programmes, selective insecticides such as insect growth regulators, attractants (pheromones) or *Bacillus thuringiensis* are used to control grape berry moths, the key pests in viticulture. These insecticides have no side-effect on the vector. In Trentino and Lombardy (Italy) their use in IP might have led to the unexpected establishment of *Scaphoideus titanus* (Mattedi & Mescalchin, 2002) and might have accelerated the spread of the disease (Belli *et al*., 2000).

Sulphur and paraffin oil application are applied at bud break in spring against overwintering eggs of various pests and could reduce *Scaphoideus* populations (Rousseau, 1997). Rotenon, Pyrethrum and Azadirachtin, insecticides used for the control of the vector in organic production (Jonis, 2001; Santinelli *et al*., 2003; Mazzoni *et al*., 2003; Delbac *et al*., 2005) are not registered in Austria.

The clearing of abandoned vineyards is regulated in provincial legislation, yet abandoned vineyards are still common and represent a source of inoculum for various pests. Moreover, cleared vineyards and pruned wood frequently remains in the

Table 2 Survey of the risk assessment for flavescence dorée using the EPPO pest risk assessment scheme

EPPO-Decision support scheme	Score	Comment (Further comments are given in the main text)
Probability of entry	**In responding to the entry part the pathways are considered separately. Unless otherwise noted the answers refer to both pathways**	
Estimate the number of relevant pathways, of different commodities, from different origins, to different end uses	2	Two types of pathways need to be considered: Pathway 1: Trade with planting material of *Vitis vinifera* from 6 countries where the disease occurs Pathway 2: Spread of infested vector, naturally or with human assistance
Is the prevalence of the pest on the pathway at origin likely to be high, taking into account factors like the prevalence of the pest at origin, the life stages of the pest, the period of the year?	Pathway 1: 4 Pathway 2: 4	(Pathway 1) Flavescence dorée is common in France, Northern Italy and parts of Serbia. It was detected in small parts of Spain and Switzerland. In Portugal the pathogen was isolated only from infected vectors. The period of the year has no influence on the prevalence of the phytoplasma in the rootstock (Pathway 2) *S. titanus* is widespread in Slovenia near to the Austrian border and in parts of the region Friuli-Venezia-Giulia. (In Hungary and Croatia the presence of both vector and diseases has not yet been confirmed, though symptoms of Grapevine Yellows are widespread there)
Is the prevalence of the pest on the pathway at origin likely to be high, taking into account factors like cultivation practices, treatment of consignments?	Pathway 1 & 2: 2–3	In all countries where the disease is present control measures including both strategies to reduce the inoculum of the disease and insecticide control of the vector are obligatory (In terms of the efficacy of these measures see main text)
How large is the volume of the movement along the pathway?	Pathway 1: 5 Pathway 2: 3	(Pathway 1) Rootstocks and grafted vines are imported from France and Italy (and, to a lesser extent, also from Spain) to Austria (see main text). Austrian nurseries particularly depend on imports of rootstocks (Pathway 2) Hundreds of specimen of *S. titanus* were caught at observation plots close to the river 'Mur'
How frequent is the movement along the pathway?	Pathway 1: 3 Pathway 2: 2	(Pathway 1) Trade of planting material is confined to the winter months (Pathway 2) Flight period of the vector is restricted to a short period in late summer
How likely is the pest to survive during transport/storage?	Pathway 1: 5	(Pathway 1) The phytoplasma is located in the phloem of the rootstocks and is hardly affected by transport (Pathway 2) Not applicable
How likely is the pest to multiply/increase in prevalence during transport/storage?	Pathway 1: 1	(Pathway 1) Multiplication of the phytoplasma during transport can be excluded (Pathway 2) Not applicable
How likely is the pest to survive or remain undetected during existing phytosanitary measures?	Pathway 1: 3 Pathway 2: 4	(Pathway 1) Field symptoms might be confused with symptoms caused by other pathogens; moreover the phytoplasma is disseminated in a latent stage on tolerant rootstocks. It is concluded that visual inspections are not sufficient to detect latent infections of flavescence dorée (Pathway 2) Currently growers do not monitor the occurrence of the vector
How widely is the commodity to be distributed throughout the PRA area?	Pathway 1a: 2 Pathway 1b: 4	(Pathway 1) Two cases need to be assessed separately: a. Rootstocks are usually imported by nurseries. There they are grafted and kept for one season before they are resold to the farmers. In the first year the distribution is limited to a few nurseries b. Grafted vines are resold to farmers shortly after import. They can be assumed to be widely distributed in the viticulture area
Do consignments arrive at a suitable time of year for pest establishment, how likely is the pest to be able to transfer from the pathway to a suitable host?	5	Consignments arrive during dormancy in winter. The phytoplasma is located in the commodity (rootstocks, scions, grafted vine), which is a suitable host
How likely is the intended use of the commodity (e.g. processing, consumption, planting) to aid transfer to a suitable host?	5	The intended use of the commodity is planting in vineyards/ nurseries.

Table 2 *Continued*

EPPO-Decision support scheme	Score	Comment (Further comments are given in the main text)
Probability of establishment	**In responding the following sections disease and vector are considered as a unit**	
How widespread are the host plants in the PRA area?	4	*Vitis vinifera*, the main host is cultivated on an area of 52 000 ha. *Vitis riparia* and *Clematis vitalba* can act as healthy carriers of the disease. *Clematis* sp. are widespread on wasteland and waysides
How likely is the pest to become associated with the vector?	2	First evidence of the vector was in 2004 in a small part of the PRA-area in Southern Styria. In 2005 and 2006 the occurrence of the vector was restricted to five locations in this part of the PRA-area
How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the area of current distribution?	4	The climatic conditions in Austrian vine-growing regions are to a large extent comparable with those in the northernmost area of its current distribution. In some parts of the PRA-area wine is grown along rivers on south-facing slopes. Such a microclimate facilitates establishment
How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the area of current distribution?	5	Topography and wind direction might affect the spread of infested vector populations. They are likely to be similar to the area of current distribution
How likely is it, that the establishment cannot be prevented by competition from existing species in the PRA area?	5	There is no evidence that the establishment and spread of the disease or the vector was prevented by naturally existing competitors
How likely is it, that the establishment cannot be prevented by natural enemies already present in the PRA area?	5	In the region of origin, Finger Lakes, USA, *Scaphoideus* sp. are parasitized by *Dryinidae* and *Pipunculidae* (Malausa, 2003). No data are available on the occurrence of natural enemies in Austria. *S. titanus* has been introduced to many new areas; it is assumed to be unlikely that establishment could be prevented by natural enemies
To what extent is the managed environment in the PRA area favourable for establishment?	4	Abandoned vineyards are common and represent a source of inoculum for various pests. Cleared vineyards and pruned wood frequently remains in the vicinity of the vineyard allowing the vector to complete its life cycle. Moreover, pruning is recommended as a measure against widespread Stolbur phytoplasma and might mask symptoms of flavescence dorée
Are existing control or husbandry measures likely to aid the establishment of the pest?	3–4	The use of broad spectrum insecticides is restricted in sustainable production, which covers > 70% of total viticulture area. Sulphur and paraffin oil application applied at bud break in spring against winter eggs of various pests can reduce *Scaphoideus* populations
How likely is it that the eradication of the pest from the PRA area is impossible, once it is established?	3	The spread of flavescence dorée depends on the occurence of one single vector, which is monophagous on *Vitis* sp. and can be controlled by insecticides. It is possible to eradicate flavescence dorée, but the early detection of vector and disease occurrence is critical for success
How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?	1–2	In Austria *S. titanus* would be at the north-eastern range of its expansion. It has a long life cycle, depends on one host genus and has only one generation per year
How likely are relatively small populations or populations of low genetic diversity to become established?	4	The example of Val d'Aosta (Italy), where an isolated population of *Scaphoideus titanus* is established, shows that this is possible
How adaptable is the pest?	3	In the past two decades the vector has adapted to different European climates. At least two molecularly distinguishable strains of flavescence dorée are known
How often has the pest been introduced into new areas outside its original area of distribution?	4	Flavescence dorée was introduced in France, Italy, Spain, Switzerland, Serbia and Portugal. In France and Italy outbreaks in several different vine-growing regions have been recorded during recent decades

Table 2 *Continued*

EPPO-Decision support scheme	Score	Comment (Further comments are given in the main text)
Probability of spread		
How likely is the pest to spread rapidly in the PRA area by natural means?	5	*Scaphoideus titanus* is extremely mobile and very effective in transmitting the phytoplasma. Infected vectors remain inoculative for the rest of their life and are able to infect a plant on each feeding event Infection may occur at any time from the beginning of June (young larvae) until late September (adults). Valley winds have shown to spread infested vector populations
How likely is the pest to spread rapidly in the PRA area by human assistance?	4	The phytoplasma is spread by plant propagation material; infested vectors might spread along traffic routes with plants for planting
How likely is it that the spread of the pest could be contained within the PRA area?	3	The example of Spain, where flavescence dorée was detected in 1996 in one location and has not spread since then, demonstrates that containment is possible. Early recognition of pest and vector and the availability of efficient eradication measures is critical to success. Once flavescence dorée and its vector are widespread monitoring and eradication programmes cannot prevent regularly new outbreaks
Potential economic impact		
How important is the effect of the pest on crop yield and/or quality to cultivated plants or on control costs caused by the pest within its area of current distribution?	4–5	Without control of the vector, flavescence dorée is an epidemic disease that has destroyed large areas of vineyards since the 1950s. It reduces vitality and yield and the quality of wine by reducing the sugar content, and increasing acidity and bitter taints. In countries where the disease occurs, substantial efforts to contain it are made
How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area?	4–5	Some of the varieties described as susceptible are of importance in Austria, especially Riesling varieties. The varieties Chardonnay, Cabernet Sauvignon, Pinot Gris and Pinot Noir are of local importance
How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?	4	Production costs are increased due to additional labour costs, costs for insecticide applications, monitoring and eradication campaigns
How great a reduction is the pest likely to cause on consumer demand in the PRA area?	1–2	Although unlikely to happen, use of clusters from diseased grapes would decrease the quality of the wine and the consumer demand
How important is environmental damage caused by the pest within its area of current distribution?	2	No evidence for a direct negative effect of the pest on the environment. The control of the vector necessitates the use of broad spectrum insecticides with side-effects on components of the ecosystem (e.g. beneficials).
How important is the environmental damage likely to be in the PRA area?	3	In Austria, sustainable production systems (integrated or organic) predominate, with a share of approximately 72% of the cultivated grapevine area. Since broad-spectrum insecticides are banned from sustainable production, their use in controlling the vector would have a significant effect on populations of beneficial organisms
How important is social damage caused by the pest within its area of current distribution and how important is it likely to be in the PRA area?	2	Social damage arises from public costs for monitoring, eradication and from loss of income of farmers and nurseries. With 2.08 ha the average viticulture area is relatively low in Austria (France: 6.15 ha; Spain: 4.25 ha) (Eurostat, 2003). The establishment of flavescence dorée could lead to farm closures, especially of small farms
How likely is the presence of the pest in the PRA area to cause losses in export markets?	2	The presence of flavescence dorée would have a negative effect on nursery trade of planting material to countries where the disease does not occur

vicinity of the vineyard. Pruning is recommended as a measure against Stolbur and may mask infections of flavescence dorée. Since the infection is systemic, pruned infected vines are still sources of inoculum.

Economic significance

S. titanus completes the whole of its life cycle on grapevines. In a vineyard it is extremely mobile and therefore responsible for the typical epidemic spread of flavescence dorée (Boudon-Padieu, 1999). The instars acquire the phytoplasma from infected vines, with nymphs from the 3rd instar onwards and adults being more infective than the first and second instar (Bressan *et al*., 2006). Depending on the intensity of infection, flavescence dorée affects the vitality, the yield and the quality of vine by high acid and low sugar contents of infected clusters.

When no control of the vector has been undertaken, the number of infected vines may increase steadily 10-fold every year and may reach 80–100% within a few years (Smith *et al*., 1997). In France and Corsica flavescence dorée has destroyed large areas and is still progressing in spite of mandatory uprooting of the diseased stocks and mandatory insecticide control of the vector (Smith *et al*., 1997). In the region of Aleksandrovac (Serbia) over 800 ha of vineyards have been destroyed. Primary economic losses due to lost investment have reached 3.2 million EUR. Reduction in producer profits due to decreased wine production is assumed to be even greater (Anonymous, 2005).

Information on the susceptibility of some Austrian main varieties (Grüner Veltliner, Müller Thurgau, Pinot Blanc, Blauer Zweigelt, Blaufränkisch, Blauer Portugieser) is lacking. Some of the varieties described as susceptible are of major importance in Austria: Welschriesling and Rhine Riesling are main varieties (4323 ha and 1643 ha, respectively; Bauer, 2002). The varieties Cabernet Sauvignon (312 ha), Pinot Gris (293 ha) and Pinot Noir (409 ha) and Chardonnay are of local importance.

Conclusions of the pest risk assessment and the endangered area

1 The highest risk of introduction of flavescence dorée arises with the extensive trade in planting material
- **1.1** Existing phytosanitary measures in the production of planting material cannot always prevent the unintended dissemination of flavescence dorée
- **1.2** Visual inspections during the certification process are insufficient to detect latent infections, which occur especially on flavescence dorée-tolerant rootstocks.

2 A certain risk arises from the spread of the vector from Slovenia/Serbia and Friuli-Venezia-Giulia, Italy especially for vineyards located along highways, railroads and waterways

3 Areas in which the vector is present are highly endangered. In these areas, any use of infested planting material could cause an epidemic of flavescence dorée. At the moment this area is restricted to parts of Southern Styria

4 Southern Styria marks the north-eastern border of the vector's current spread but, since *S. titanus* has established populations in different environmental zones in Europe, it cannot be assumed that climate would prevent establishment in the vine-growing regions in the north, especially with regards to global warming and the favourable microclimate for *S. titanus* on slopes

5 Therefore the endangered area is the entire Austrian viticulture area

6 Current plant protection practice cannot prevent the establishment of vector populations

7 Flavescence dorée is only transmitted by *Scaphoideus titanus*, which is monophagous on *Vitis* and can be controlled by insecticides. There is a possibility for it to be contained or even eradicated, but an early detection of vector and disease occurrence and the immediate initiation of appropriate eradication measures are critical to success

8 Otherwise one must reckon that flavescence dorée and its vector would establish and spread rapidly in the PRA-area, causing serious effects on crop yield and quality of wine. While losses to vinegrowers following establishment would be substantial, establishment would also result in high follow-up costs for monitoring, eradication campaigns and additional efforts in the production and the certification of planting material.

Conclusions

Risk management options

Following the conclusions of the risk assessment, different applicable measures are considered. Currently the possibility that the disease and the vector will become associated is restricted to parts of Southern Styria. The aim of the following recommendations is to prevent the entry of the disease and its vector and to minimise impacts of established populations of *S. titanus* in southern Styria.

Preventive measures in regions found free of flavescence dorée and *S. titanus*

Monitoring surveys confirmed that both disease and vector are absent in over 99% of the Austrian viticulture area. Nevertheless the following provisions should be implemented in order to prevent introduction of the vector and the disease:

1 Laboratory investigations on the cause of grapevine yellows symptoms in the field, especially if they are epidemic or occur in newly planted vineyards

2 Monitoring of the vector at selected observation points where the first appearance can be expected: in vineyards along traffic routes, waterways and on exposed slopes.

Preventive safeguard measures against the vector, such as broad spectrum insecticide applications are not recommended.

Recommended measures in regions where the vector, *S. titanus*, has been found

This situation applies to the vine-growing region of Southern Styria.

Measures to be implemented by the provincial authorities

On the basis of the risk assessment the following action plan should be implemented in provincial legislation:

1 Laboratory testing of propagated plant material in nurseries in addition to the official visual inspections according to legal certification requirements

2 Compulsory control of the vector: sulphur or paraffin oil applications applied at bud break in spring against overwintering eggs and chemical treatments against larvae and adults during summer

3 Thorough implementation of existing provincial rules legislating the obligatory uprooting of abandoned vineyards.

Additional recommendations for vine growers and advisors

1 Laboratory testing of grapevines with symptoms of grapevine yellows disease

2 Monitoring of *S. titanus* migration along the river 'Mur' and along traffic routes around the currently infested areas and molecular analyses of the trapped vectors

3 If new vineyards are planted special care should be taken about the quality of the planting material. Wherever possible rootstocks should be used from regions found free from flavescence dorée. If this is not possible, it is strongly recommended that laboratory analysis is performed to confirm that the planting material is not infested.

Modification concerning the EC-directive 2000/29

The measures laid down in Annex IV AII 17., concerning the specific requirements at the place of production should be modified by including laboratory testing of motherplants for the production of rootstocks, because of the possibility of latent infections.

For Austrian regions in which the vector is established, the specification of pest-free areas as protected zones according to the Annexes of EC Dir. 2000/29 should be envisaged.

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Analyse du risque phytosanitaire du Grapevine flavescence dorée phytoplasma pour la viticulture autrichienne

En 2004, *Scaphoideus titanus*, vecteur du Grapevine flavescence dorée phytoplasma, a été signalé pour la première fois dans les vignobles autrichiens. L'absence du phytoplasme en 2004–2006 a été confirmée par des analyses moléculaires d'échantillons de vigne et de vecteur. Pour estimer le risque pour la viticulture autrichienne une Analyse de risque phytosanitaire (ARP) a été conduite, suivant le schéma d'aide à la décision de l'OEPP. Le plus grand risque d'introduction provient du commerce intense de porte-greffe et, en particulier pour les vignes situées près de grandes routes et autoroutes, de la dissémination passive ou active du vecteur. Le climat ne limitera pas l'établissement du vecteur dans les importantes régions viticoles du nord de l'Autriche, Niederösterreich et Burgenland. A présent, la probabilité que la maladie et le vecteur s'associent est limitée à certaines partie du sud de la Styria. La pratique phytosanitaire ne peut pas empêcher l'établissement et la dissémination des populations du vecteur, en particulier les systèmes de production durable, qui constituent plus de 70% de la surface totale de la viticulture autrichienne. La possibilité d'enrayement ou même d'éradication est donnée, mais exige une reconnaissance précoce du vecteur et de la maladie et l'initiation immédiate de mesures. Sinon les pertes des viticulteurs, des coûts consécutifs pour l'éradication et les efforts supplémentaires dans la production de plantes seraient substantiels. Après l'évaluation, des mesures réglementaires et des recommandations pour éviter l'entrée de la maladie et pour minimiser l'impact de l'établissement de populations du vecteur sont considérées.

Анализ фитосанитарного риска для австрийского виноградарства фитоплазмы виноградной лозы flavesence dorée

В 2004 г. *Scaphoideus titanus*, переносчик фитоплазмы виноградной лозы flavescence dorée, был впервые зарегистрирован на виноградниках Австрии. Отсутствие фитоплазмы в 2004–2006 гг. было подтверждено молекулярными исследованиями виноградной лозы и образцов переносчика. В Австрии был проведен Анализ Фитосанитарного Риска (АФР) в соответствии со схемой ЕОКЗР, разработанной для принятия решений. Наиболее высокий риск интродукции возникает в результате расширенной торговли подвоями, главным образом, он существует для виноградников, расположенных вдоль автодорог и водных путей сообщения, из-за пассивного или активного распространения этого переносчика. Климатические условия не ограничивают акклиматизацию переносчика в обширных северных областях Нижней Австрии и провинции Бургенланд, где виноград выращивается традиционно. В настоящее время вероятность того, что болезнь и переносчик объединятся, ограничена отдельными частями южной Стирии. Практика защиты растений не может предотвратить акклиматизацию и распространение популяций переносчика, особенно в устойчивых системах производства, представляющих собой более 70% всей зоны виноградарства Австрии. В статье показана возможность сдерживания и даже ликвидации, однако это требует раннего выявления переносчика и болезни, а также незамедлительного принятия мер. В противном случае потери для производителей винограда, последующие затраты на ликвидацию и дополнительные усилия при производстве растений будут весьма существенными. После этой оценки рассматриваются законодательные меры и рекомендации по предотвращению завоза этой болезни и минимизации воздействия акклиматизировавшихся популяций переносчика.

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