

Research article

Sensitivity of *Phytophthora palmivora* Causing Durian Diseases to Metalaxyl-M and Dimethomorph in Southern and Eastern Thailand

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Abstract

Metalaxyl-M (Met-M) and dimethomorph (Dim) are two systemic fungicides commonly used in Thailand to treat durian rot diseases caused by *Phytophthora palmivora*, a pathogen that significantly affects durian production. Fungicides have long been used by Thai durian farmers to control this infection, but managing the disease has become increasingly challenging in recent years. Monitoring fungicide resistance evolution is essential for effective disease management. In 2020 and 2022, eighty-one and sixty isolates, respectively, were collected from naturally infected durians in southern and eastern Thailand. All isolates were identified as *P. palmivora* through sporangium formation. Furthermore, 23 out of the 141 isolates were confirmed as *P. palmivora* based on sequencing of the internal transcribed spacer (ITS) and 5.8S regions of rDNA. All isolates were tested for mycelium growth sensitivity to Met-M and Dim. EC₅₀ values were used to classify sensitivity into three categories: sensitive (S) at EC₅₀ < 1 mgL⁻¹, moderately resistant (MR) at EC₅₀ between 1 and 100 mgL⁻¹, and resistant (R) at EC₅₀ > 100 mgL⁻¹. In southern Thailand, 58% of the isolates were Met-M^RDim^S, and 41.25% were Met-M^SDim^S. In eastern Thailand, 36.67% were Met-M^{MR}Dim^S, and 41.67% were Met-M^SDim^S. These findings indicate that the populations of *P. palmivora* in the durian orchards in southern and eastern Thailand consisted of a mixture of sensitive, moderately resistant, and resistant strains.

Keywords: fungicide sensitivity; durian diseases; *Phytophthora palmivora*; metalaxyl-M; dimethomorph

1. Introduction

Durian (*Durio zibethinus* L.) is the king of tropical fruits and one of Thailand's most valuable economic fruits, commanding a high price. It can be grown in all regions of Thailand, with

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the southern and eastern regions having the most planting area. The Department of Agricultural Promotion reported that Thailand exported durians worth USD 3.219 billion in 2022, including fresh and frozen durians (Office of Agricultural Economics, 2023). Thailand has the largest durian export market, accounting for 93.3% global market share where the major markets are China, Hong Kong, and Taiwan. In this regard, Vietnam and Malaysia are significant competitors in the durian trade. However, root rot, stem rot, and fruit rot diseases caused by pathogens in the genus *Phytophthora* are key constraints in durian production. The southern and eastern parts of Thailand have high rainfall and high humidity, creating an environment that is highly conducive to outbreaks of *Phytophthora* diseases (Drenth & Guest, 2004; Suksiri et al., 2018). This pathogen can spread in air and water with rapid multiplication of inoculum-sporangia and motile zoospores. It produces chlamydospores and oospores for survival outside the host, and the disease cycle is driven by free water and high humidity (Lim & Sangchote, 2003; Drenth & Guest, 2004; Abad & Cruz, 2012). Most Thai durian farmers have used multiple chemical fungicide groups for controlling *Phytophthora* species, for example, phenylamides (metalaxyl, metalaxyl-M), phosphonates (fosetyl-Al, phosphorous acid), carboxylic acid amides (dimethomorph), or dithiocarbamates (mancozeb, maneb), and so on (Knowledge Management Team, Office of Agricultural Research and Development Region 6, 2022). Although these fungicides effectively suppress and control diseases, their long-term use may lead to reduced effectiveness due to the evolution of pathogen resistance to fungicides. Such an increase in fungicide-resistant strains in pathogen populations results in economic problems (Deising et al., 2008; Ishii & Hollomon, 2015). The issue of chemical resistance in *Phytophthora palmivora*, particularly in the context of durian cultivation, has become increasingly critical due to the widespread use of fungicides such as metalaxyl. This pathogen is responsible for significant losses in durian production, causing root and stem rot diseases that can devastate crops (Kongtragoul et al., 2021; Numba, 2023). Metalaxyl, a phenylamide fungicide, has been effective against various *Phytophthora* species; however, its overuse has led to the development of resistant strains, complicating disease management strategies (Cui et al., 2018; Kongtragoul et al., 2021). Research has shown that metalaxyl resistance in *P. palmivora* is associated with specific genetic mutations that affect the pathogen's sensitivity to the fungicide. Studies have indicated that the intrinsic risk of resistance development is high due to the site-specific action of metalaxyl, which has been documented in multiple *Phytophthora* species, including *P. nicotianae* (Cui et al., 2018). Resistance mechanisms often involve alterations in the target sites of the fungicide, leading to reduced efficacy and necessitating the exploration of alternative management strategies (Kongtragoul et al., 2021; Zhang et al., 2022). To help develop effective strategies for controlling *Phytophthora* diseases, in this research, we monitored the fungicide sensitivity of *Phytophthora* isolates from the largest durian planting areas in Thailand. We focused on metalaxyl-M and dimethomorph because most farmers use both fungicides. Both fungicides have specific target sites; metalaxyl-M inhibits fungal ribosomal RNA polymerases, while dimethomorph targets cell wall biosynthesis via cellulose synthase inhibition (Fungicide Resistance Action Committee (FRAC), 2020).

Fungicide Resistance Action Committee (FRAC) (2020) reported on field resistance to phenylamides among *Phytophthora* species, including *P. cactorum* from crown rot of strawberry, *P. capsici* from stem rot of lima bean pods, *P. cinnamomi* from root rot of avocado, *P. erythroseptica* from pink rot of potato, *P. infestans* from late blight of potato, *P. melonis* from foot rot of cucurbits, and *P. nicotianae* from root rot of ornamentals. In Thailand, metalaxyl resistance was first reported in 2011 in *P. infestans* isolates that caused late blight of potatoes in northern Thailand (Chiampiriyakul et al., 2011). Subsequently, Kongtragoul et al. (2021) reported that nine out of twenty isolates of *P.*

palmivora associated with durian diseases in southern Thailand during 2016-2017 were resistant to phenylamide fungicides. Similarly, Somnuek et al. (2023) found that 24 out of 40 *P. palmivora* isolates exhibited resistance to metalaxyl, with EC₅₀ values exceeding 100 mg/L, in eastern and southern Thailand in 2023. Dimethomorph resistance has not yet been reported in Thailand. However, Tongsri et al. (2023) reported that all *P. palmivora* isolates were sensitive to dimethomorph in eastern Thailand. *Phytophthora palmivora* has been isolated from durian, but information on the resistance of *Phytophthora* spp. to fungicides, aside from phenylamides, remains limited in Thailand. There are significant knowledge gaps regarding resistance mechanisms and the potential for resistance development to dimethomorph in *P. palmivora*, which remain an underexplored area in Thailand. Monitoring of fungicide resistance is crucial for supporting sustainable durian disease management strategies.

To address the challenge of chemical resistance, integrated pest management (IPM) strategies are being recommended for durian growers. These strategies include the use of resistant cultivars, cultural practices, and biological control methods (Kongtragoul et al., 2021; Numba, 2023). For example, potassium phosphite has been suggested as an effective alternative to metalaxyl, offering a different mode of action that may help mitigate resistance issues (Zhang et al., 2022). Furthermore, the efficacy of various fungicides has been evaluated in the context of *Phytophthora* management. Studies have indicated that while metalaxyl remains one of the most effective substances for controlling *Phytophthora*, its effectiveness can vary based on environmental factors and the specific strain of the pathogen (Rosário et al., 2021). Continuous monitoring of *Phytophthora* populations and their resistance profiles is essential for the sustainable management of durian crops (Kongtragoul et al., 2021; Zhang et al., 2022). Therefore, the aims of this research were (i) to survey and collect *Phytophthora* isolates from naturally infected durians in commercial orchards under pressure of fungicide resistance in southern and eastern Thailand, (ii) to identify them based on morphological characterization and analyze their internal transcribed spacer (ITS) and 5.8S regions of rDNA to identify the species, and (iii) to evaluate the metalaxyl-M and dimethomorph sensitivity in both regions.

2. Materials and Methods

2.1 Locations

Disease samples of the fruit, branch, and stem of 'Monthong' durian that showed natural infection were collected in 2020 and 2022 from 10 locations in the southern region (6 locations in Chumphon, 2 locations in Surat Thani, and 2 locations in Ranong) and 10 locations in the eastern region (6 locations in Chanthaburi, 2 locations in Rayong, and 2 locations in Trat) of Thailand. Sampling did not occur in 2021 due to COVID-19 restrictions. Five to ten strains were collected per location, with sampling areas spaced approximately 2-3 km apart. Geographic details are provided in Table 1.

2.2 Isolation and identification

2.2.1 Isolation

The plant tissue from the margin between the diseased and healthy areas was cut into approximately 5 x 5 mm pieces and surface sterilized by soaking in 10% Clorox® solution

Table 1. List of durian orchards with details of each location

Year	Province	District	Sub-district	Location Code	GPS				
					Latitude	Longitude			
2020	Southern	Chumphon	Mueang	Tham Sing	CL1	10° 24´ 55″N 99°03´33″E			
			Sawi	Na Sak	CL2	10° 13´ 56″N 99° 00´02″E			
			Thun Tako	Thung Takhrai	CL3	10° 08´ 25″N 99° 06´26″E			
			Tha Sae	Hong Charoen	CL4	10° 48´ 36″N 99° 06´59″E			
			Pathio	Khao Chai Rat	CL5	10° 54´ 51″N 99° 17´04″E			
			Tha Sae	Rap Ro	CL6	10° 51´ 59″N 99° 03´15″E			
	Suratthani	Ban Na Doem	Na Tai	SL1	08° 55´ 45″N 99° 20´56″E				
			Mueang	Khunthale	SL2	09° 01´ 43″N 99° 20´01″E			
	Ranong	Kra Buri	Lam Liang	RL1	10° 19´ 40″N 98° 48´33″E				
			Cho Po ro	RL2	10° 38´ 35″N 98° 55´36″E				
	Eastern	Chanthaburi	Makham	Tha Luang	ChL4	12° 40´56″N 102° 8´46″E			
					Rayong	Khao Chamao	Cham Kho	RYL1	12° 53´45″N 101°37´52″E
	2022	Eastern	Chanthaburi	Khlung	Trok Nong	ChI1	12° 32´22″N 102°16´34″E		
Khlung				Trok Nong	ChI2	12° 31´59″N 102°15´42″E			
Na Yai Am				Wang Tanot	ChI3	12° 42´24″N 101° 57´02″E			
Na Yai Am				Wang Tanot	ChI4	12° 41´18″N 101° 55´51″E			
Na Yai Am				Sanamchai	ChI5	12° 39´51″N 101° 53´32″E			
Na Yai Am				Na Yai Am	ChI6	12° 43´58″N 101° 51´05″E			
Rayong		Klaeng	Huai Yang	RyL2	12° 48´44″N 101°32´28″E				
				Trat	Mueang	Laem Klat	TrL1	12° 07´33″N 102°41´06″E	
			Mueang	Laem Klat	TrL2	12° 08´14″N 102°40´38″E			

for 1-2 min, rinsed with sterile distilled water, and blotted dry on sterile paper towels. The dried tissues were placed on a PAR (PH)-V8 selective medium and incubated at room temperature (RT) of approximately 28-30°C. Isolate designation: Isolates were coded using the following format: Province [C = Chumphon, S = Surat Thani, R = Ranong, Ch = Chanthaburi, Ry = Rayong, Tr = Trat], Location [L1 = Location 1, L2 = Location 2, L3 = Location 3, L4 = Location 4, L5 = Location 5, L6 = Location 6], Tissue part [S = Stem, B = Branch, F = Fruit] and , Isolate number [1, 2, 3, etc.]. For example: CL1_S1 represents an isolation from Chumphon, Location 1, durian stem, isolate number 1.

2.2.2 Identification

The morphological identification of the *Phytophthora* species was based on IDphy, an international online resource (<https://idtools.org/id/phytophthora/results.php?terms=palmivora>) and the published description (André & Sendall, 2001; Abad et al., 2023). Key characteristics for *P. palmivora* include colonies with no distinctive pattern (uniform, radial, stellate, chrysanthemum, and rosette) and sporangia that are caducous with short pedicels and variable in shape (globose, ovoid, obpyriform, ellipsoid and irregular) originated from simple sympodial sporangiophores.

The total DNA was extracted using the DNeasy®Plant Mini Kit (QIAGEN, Hilden, Germany). The extracted DNA served as template for amplification with ITS1 (5'-TCCGTAGGTGAACCTGCGG-3') and ITS4 (5'TCCTCCGCTTATTGATATGC-3') of the internal transcribed spacer (ITS) of rDNA regions using polymerase chain reaction (PCR) (White et al., 1990). The PCR products were directly sequenced using cycle sequencing with ITS1 and ITS4 primers from Axil Scientific Pte Ltd., Singapore. Sequence similarity analyses were performed using the Basic Local Alignment Search Tool (BLAST) from the National Center for Biotechnology Information (NCBI) GenBank database.

2.3 Fungicide sensitivity assay

Commercial formulations of the fungicides shown in Table 2 were used in this experiment. The fungicide sensitivity to metalaxyl-M and dimethomorph of all tested isolates was assessed by a mycelial growth assay performed on clarified V8 juice agar culture plates. After autoclaving, the medium was amended with 0, 0.1, 1, 10, and 100 mgL⁻¹ (a.i.) of each fungicide. Mycelial discs, 4 mm in diameter, were cut from actively growing colony margins and transferred upside down to the plates before incubating at room temperature (28-30°C). After incubation for 3 days, the colony diameters of isolates grown on the fungicide-amended and unamended medium were recorded, and the percentage of mycelial growth inhibition by fungicides was calculated.

Table 2. Fungicides used to determine the *in vitro* sensitivity of *Phytophthora* spp. in this study

Chemical Group	Chemical Name	Distribution in Plant	Formulation Type	Active Ingredient
Phenylamides	Metalaxyl-M	Systemic	Emulsions for seed treatment (ES)	35% w/v
Carboxylic acid amides	Dimethomorph	Systemic	Suspension concentrate (SC)	50% w/v

2.4 Data analysis of fungicide sensitivity

Mycelial growth inhibition (%) values were plotted as probits versus the log₁₀ of the fungicide concentration (mgL⁻¹) and analyzed by linear regression. The regression equation estimated the 50% effective concentration (EC₅₀) to inhibit each isolate's mycelial growth. The EC₅₀ values were used to identify three categories of sensitivity to both fungicides, which were based on Peters et al. (2001) and Tian et al. (2016) as follows: sensitive (S) = EC₅₀ < 1 mgL⁻¹, moderately resistant (MR) = EC₅₀ 1-100 mgL⁻¹, and resistant (R) = EC₅₀ > 100 mgL⁻¹.

3. Results and Discussion

3.1 Collection and isolation

Naturally infected durian fruit, branch, and stem samples that showed typical rot symptoms were collected from twenty commercial durian orchards in Thailand, including the 10 southern locations [Chumphon (n=6), Surat Thani (n=2), and Ranong (n=2)] and the 10

eastern locations [Chanthaburi (n=6), Rayong (n=2), and Trat (n=2)] in 2020 and after covid19 in 2022. All durian orchards were commercial fields that had been regularly treated with fungicides, typically applied every 7-10 days, or 2-3 times per month during the rainy season. Metalaxyl, metalaxyl-M, and dimethomorph were applied via spraying or trunk painting, often mixed with mancozeb to control *Phytophthora* diseases. Fruit rot (Figure 1a), stem rot, and branch rot (Figure 1b) samples that showed natural infection were collected from durian orchards in southern and eastern Thailand in 2020 and 2022. One hundred and forty-one isolates were successfully isolated from 10 locations in southern Thailand and 10 locations in eastern Thailand (Table 3). Eighty-one and six isolates were collected from the southern and eastern regions, respectively, in 2020. After COVID-19 in 2022, fifty-four isolates were collected from the east region. All isolates were identified as *Phytophthora palmivora* based on the colony (Figure 2a) and sporangium formation (Figure 2b). Each isolate was purified by single sporangium isolation, and the culture was preserved at 4°C for further study. Out of 141 isolates randomized from each location tested (Table 4), 23 isolates were identified as *P. palmivora*. Sequences analysis of the rDNA-ITS region revealed 100% aligned at of *P. palmivora* sequence from the NCBI, except for isolates CL4_S4 and CL4_F1, which showed 97.20% and 98.88% alignment, respectively. The ITS sequences of the 23 isolates were deposited in NCBI under accession numbers OR655080 to OR655102. Multiple sequence alignment was compared with reference sequence (NCBI accession number MN750015), as illustrated in Figure 3. The genus *Phytophthora* includes destructive pathogens that significantly impact Thai durian production. It infects many parts of durian tree, including roots, stems, branches, and fruits, and can ultimately lead to the death of the standing durian tree. In this study, we collected pathogen isolates from naturally infected 'Monthong' cultivars in commercial orchards across southern and eastern Thailand. All isolates were identified as *P. palmivora* based on morphological characteristics using IDphy, an international online resource, and confirmed through nucleotide sequences of the nucleotide sequences of the ITS and 5.8S regions of rDNA. Similarly, *P. palmivora* has been reported as a cause of the most destructive and economically significant disease of durian in Southeast Asia countries such as Thailand (Kongtragoul et al., 2021), Malaysia (Mohamed et al., 2019), Indonesia (Peters et al., 2001), Vietnam (Gisi et al., 1997), The Philippines (Solpot & Cumagun, 2022) and Brunei Darussalam (Sivapalan et al., 1997), as well as in other durian-producing regions like Australia (Vawdrey et al., 2005).



Figure 1. Rot symptoms of *Phytophthora* disease on fruits (a) stem and branch (b) of durian

Table 3. The number of isolates of *Phytophthora palmivora* from durian disease in each location of southern and eastern in 2020 and 2022

Year	Province	Location code	Samples			Total
			Fruits	Stem	Branch	
2020	Southern	CL1	-	13	-	13
		CL2	-	5	-	5
		CL3	-	10	-	10
		CL4	6	3	-	9
		CL5	13	-	-	13
		CL6	-	7	-	7
		SL1	-	7	1	8
		SL2	-	5	-	5
		RL1	-	5	-	5
		RL2	-	6	-	6
		Total Southern	19	61	1	81
	Eastern	ChL4	-	1	-	1
		RYL1	-	5	-	5
2022	Eastern	Chl1	-	6	-	6
		Chl2	6	-	-	6
		Chl3	6	-	-	6
		Chl4	6	-	-	6
		Chl5	6	-	-	6
		Chl6	6	-	-	6
		RyL2	-	6	-	6
		TrL1	6	-	-	6
		TrL2	6	-	-	6
		Total Eastern	42	12	-	60

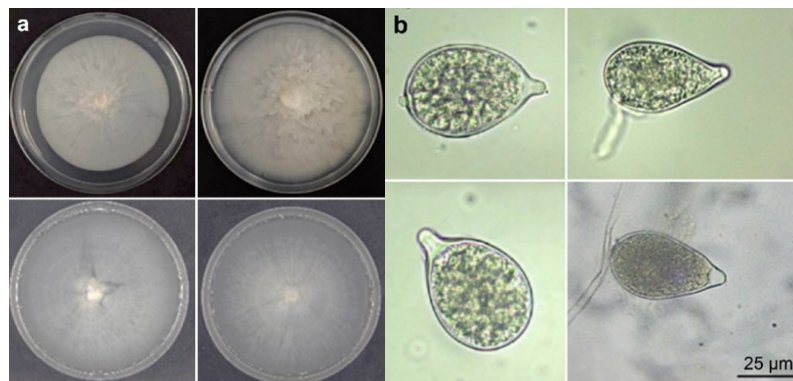
**Figure 2.** Colony characteristics (a) and sporangium (b) of *Phytophthora palmivora*

Table 4. *Phytophthora palmivora* responses to metalaxyl-M and dimethomorph by mycelial growth assay from southern Thailand in 2020 and eastern Thailand in 2020 and 2022

Location Code	Double Fungicide Sensitivity (no. isolate)								
	Met-M ^R Dim ^R	Met-M ^R Dim ^{MR}	Met-M ^R Dim ^S	Met-M ^{MR} Dim ^R	Met-M ^{MR} Dim ^{MR}	Met-M ^{MR} Dim ^S	Met-M ^S Dim ^R	Met-M ^S Dim ^{MR}	Met-M ^S Dim ^S
Southern									
CL1	-	-	12	-	-	1	-	-	-
CL2	-	-	5	-	-	-	-	-	-
CL3	-	-	2	-	-	-	-	-	8
CL4	-	-	3	-	-	-	-	-	6
CL5	-	-	2	-	-	-	-	-	11
CL6	-	-	6	-	-	-	-	-	1
SL1	-	-	3	-	-	-	-	-	5
SL2	-	-	4	-	-	-	-	-	1
RL1	-	-	5	-	-	-	-	-	-
RL2	-	-	5	-	-	-	-	-	1
Total	-	-	47	-	-	1	0	-	33
Eastern									
Chl1	-	-	-	-	-	6	-	-	-
Chl2	-	-	-	-	-	6	-	-	-
Chl3	-	-	-	-	-	3	-	-	3
Chl4	-	1	4	-	1	1	-	-	-
Chl5	-	-	-	-	2	2	-	-	4
Chl6	-	-	-	-	2	-	-	-	4
TrL1	-	-	-	-	-	-	-	1	5
TrL2	-	-	-	-	-	-	-	2	4
RYL1	-	-	-	-	-	-	-	-	5
RyL2	-	-	-	-	2	4	-	-	-
Total	-	1	4	0	5	22	-	3	25

Accession no. (isolate code)

OR655090	(CL4_F1)	--CTTCACGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	58
OR655091	(CL4_S4)	--CTCACGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	58
OR655082	(CL1_S2)	-----GTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655100	(ChL4_S2)	-----GTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655086	(CL2_S3)	-----GACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	51
OR655096	(CL5_F12)	-----AGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	54
OR655102	(RyL1_S19)	-----TGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	52
OR655101	(RyL1_S12)	-----TGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	52
OR655098	(RL1_S31)	--TTCACGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	58
OR655083	(CL1_S5)	-----TGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	52
OR655087	(CL2_S7)	-----CTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655092	(CL4_S5)	-----TGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	52
OR655094	(CL5_F6)	-----TACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	51
OR655085	(CL1_S15)	-----GACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	51
OR655093	(CL4_F10)	-----TGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655089	(CL3_S10)	-----CTGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	54
OR655088	(CL3_S6)	-TTCACGTGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	59
OR655081	(CL5-F2)	-TTCACGTGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	59
MN750015		----CGTGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	55
OR655080	(CL5-F1)	CTTCACGTGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	60
OR655084	(CL1_S9)	-----TGAACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655095	(CL5_F11)	-----GGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	51
OR655097	(RL1_S17)	-----AGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	53
OR655099	(RL1_S33)	---TTCACGTGACCGTATCAAACTTAGTTGGGGTCTCTTTCGGCGGCGGCTGCTGGCTT	57

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OR655090	(CL4_F1)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	118
OR655091	(CL4_S4)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	118
OR655082	(CL1_S2)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655100	(ChL4_S2)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655086	(CL2_S3)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	111
OR655096	(CL5_F12)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	114
OR655102	(RyL1_S19)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	112
OR655101	(RyL1_S12)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	112
OR655098	(RL1_S31)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	118
OR655083	(CL1_S5)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	112
OR655087	(CL2_S7)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655092	(CL4_S5)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	112
OR655094	(CL5_F6)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	111
OR655085	(CL1_S15)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	111
OR655093	(CL4_F10)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655089	(CL3_S10)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	114
OR655088	(CL3_S6)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	119
OR655081	(CL5-F2)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	119
MN750015		CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	115
OR655080	(CL5-F1)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	120
OR655084	(CL1_S9)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655095	(CL5_F11)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	111
OR655097	(RL1_S17)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	113
OR655099	(RL1_S33)	CATTGCTGGCGGCTGCTGTTGGGAGAGCTCTATCATGGCGAGCGTTTGGGCTTCGGTCTG	117

OR655090	(CL4_F1)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	178
OR655091	(CL4_S4)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	178
OR655082	(CL1_S2)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655100	(ChL4_S2)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655086	(CL2_S3)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	171
OR655096	(CL5_F12)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	174
OR655102	(RyL1_S19)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	172
OR655101	(RyL1_S12)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	172
OR655098	(RL1_S31)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	178
OR655083	(CL1_S5)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	172
OR655087	(CL2_S7)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655092	(CL4_S5)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	172
OR655094	(CL5_F6)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	171
OR655085	(CL1_S15)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	171
OR655093	(CL4_F10)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655089	(CL3_S10)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	174
OR655088	(CL3_S6)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	179
OR655081	(CL5-F2)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	179
MN750015		AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	175
OR655080	(CL5-F1)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	180
OR655084	(CL1_S9)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655095	(CL5_F11)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	171
OR655097	(RL1_S17)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	173
OR655099	(RL1_S33)	AACTAGTAGCTTTTTTAAACCCATTCTTTATAACTGATTATACTGTAGGGACGAAAGTCT	177

OR655090	(CL4_F1)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	238
OR655091	(CL4_S4)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	238
OR655082	(CL1_S2)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655100	(ChL4_S2)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655086	(CL2_S3)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	231
OR655096	(CL5_F12)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	234
OR655102	(RyL1_S19)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	232
OR655101	(RyL1_S12)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	232
OR655098	(RL1_S31)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	238
OR655083	(CL1_S5)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	232
OR655087	(CL2_S7)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655092	(CL4_S5)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	232
OR655094	(CL5_F6)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	231
OR655085	(CL1_S15)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	231
OR655093	(CL4_F10)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655089	(CL3_S10)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	234
OR655088	(CL3_S6)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	239
OR655081	(CL5-F2)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	239
MN750015		CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	235
OR655080	(CL5-F1)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	240

OR655084	(CL1_S9)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655095	(CL5_F11)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	231
OR655097	(RL1_S17)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	233
OR655099	(RL1_S33)	CTGCTTTTAACTAGATAGCAACTTTCAGCAGTGGATGTCTAGGCTCGCACATCGATGAAG	237

OR655090	(CL4_F1)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	298
OR655091	(CL4_S4)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	298
OR655082	(CL1_S2)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655100	(ChL4_S2)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655086	(CL2_S3)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	291
OR655096	(CL5_F12)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	294
OR655102	(RyL1_S19)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	292
OR655101	(RyL1_S12)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	292
OR655098	(RL1_S31)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	298
OR655083	(CL1_S5)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	292
OR655087	(CL2_S7)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655092	(CL4_S5)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	292
OR655094	(CL5_F6)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	291
OR655085	(CL1_S15)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	291
OR655093	(CL4_F10)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655089	(CL3_S10)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	294
OR655088	(CL3_S6)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	299
OR655081	(CL5_F2)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	299
MN750015		AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	295
OR655080	(CL5-F1)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	300
OR655084	(CL1_S9)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655095	(CL5_F11)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	291
OR655097	(RL1_S17)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	293
OR655099	(RL1_S33)	AACGCTGCGAACTGCGATACGTAATGCGAATTGCAGGATTCAGTGAGTCATCGAAATTTT	297

OR655090	(CL4_F1)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	358
OR655091	(CL4_S4)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	358
OR655082	(CL1_S2)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655100	(ChL4_S2)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655086	(CL2_S3)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	351
OR655096	(CL5_F12)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	354
OR655102	(RyL1_S19)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	352
OR655101	(RyL1_S12)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	352
OR655098	(RL1_S31)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	358
OR655083	(CL1_S5)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	352
OR655087	(CL2_S7)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655092	(CL4_S5)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	352
OR655094	(CL5_F6)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	351
OR655085	(CL1_S15)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	351
OR655093	(CL4_F10)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655089	(CL3_S10)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	354
OR655088	(CL3_S6)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	359
OR655081	(CL5-F2)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	359
MN750015		GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	355
OR655080	(CL5-F1)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	360
OR655084	(CL1_S9)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655095	(CL5_F11)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	351
OR655097	(RL1_S17)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	353
OR655099	(RL1_S33)	GAACGCATATTGCACTTCCGGGTTAGTCCTGGGAGTATGCCTGTATCAGTGTCCGTACAT	357

OR655090	(CL4_F1)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	418
OR655091	(CL4_S4)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	418
OR655082	(CL1_S2)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655100	(ChL4_S2)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655086	(CL2_S3)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	411
OR655096	(CL5_F12)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	414
OR655102	(RyL1_S19)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	412
OR655101	(RyL1_S12)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	412
OR655098	(RL1_S31)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	418
OR655083	(CL1_S5)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	412
OR655087	(CL2_S7)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655092	(CL4_S5)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	412
OR655094	(CL5_F6)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	411
OR655085	(CL1_S15)	CAAACCTTGGTTTTCTTCCCTCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	411

OR655093	(CL4_F10)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655089	(CL3_S10)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	414
OR655088	(CL3_S6)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	419
OR655081	(CL5-F2)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	419
MN750015		CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	415
OR655080	(CL5-F1)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	420
OR655084	(CL1_S9)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655095	(CL5_F11)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	411
OR655097	(RL1_S17)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	413
OR655099	(RL1_S33)	CAAACCTTGGTTTTCTTCCCTCCCGTGTAGTCGGTGGTGGATGTGCCAGATGTGAAGTGTCT	417

OR655090	(CL4_F1)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	478
OR655091	(CL4_S4)	TGCGGCTGGGCTTCTGATCCGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	478
OR655082	(CL1_S2)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655100	(ChL4_S2)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655086	(CL2_S3)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	471
OR655096	(CL5_F12)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	474
OR655102	(RyL1_S19)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	472
OR655101	(RyL1_S12)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	472
OR655098	(RL1_S31)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	478
OR655083	(CL1_S5)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	472
OR655087	(CL2_S7)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655092	(CL4_S5)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	472
OR655094	(CL5_F6)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	471
OR655085	(CL1_S15)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	471
OR655093	(CL4_F10)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655089	(CL3_S10)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	474
OR655088	(CL3_S6)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	479
OR655081	(CL5-F2)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	479
MN750015		TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	475
OR655080	(CL5-F1)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	480
OR655084	(CL1_S9)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655095	(CL5_F11)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	471
OR655097	(RL1_S17)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	473
OR655099	(RL1_S33)	TGCGGCTGGTCTTCGGATCGGCTGTGAGTCCTTTGAAATGTACTGAAGTGTACTTCTCTT	477

OR655090	(CL4_F1)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	538
OR655091	(CL4_S4)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	538
OR655082	(CL1_S2)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655100	(ChL4_S2)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655086	(CL2_S3)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	531
OR655096	(CL5_F12)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	534
OR655102	(RyL1_S19)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	532
OR655101	(RyL1_S12)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	532
OR655098	(RL1_S31)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	538
OR655083	(CL1_S5)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	532
OR655087	(CL2_S7)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655092	(CL4_S5)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	532
OR655094	(CL5_F6)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	531
OR655085	(CL1_S15)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	531
OR655093	(CL4_F10)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655089	(CL3_S10)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	534
OR655088	(CL3_S6)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	539
OR655081	(CL5-F2)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	539
MN750015		TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	535
OR655080	(CL5-F1)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	540
OR655084	(CL1_S9)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655095	(CL5_F11)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	531
OR655097	(RL1_S17)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	533
OR655099	(RL1_S33)	TGCTCCAAAAGCGTGGCGTTGCTGATTGTGGAGGCTGCTTGCGTAGCCAGTCTGGCGACC	537

OR655090	(CL4_F1)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	598
OR655091	(CL4_S4)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	598
OR655082	(CL1_S2)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	593
OR655100	(ChL4_S2)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	593
OR655086	(CL2_S3)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	591
OR655096	(CL5_F12)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	594
OR655102	(RyL1_S19)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	592
OR655101	(RyL1_S12)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGTATGGTTGGCTTCGGC	592

OR655098	(RL1_S31)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	598
OR655083	(CL1_S5)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	592
OR655087	(CL2_S7)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	593
OR655092	(CL4_S5)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	592
OR655094	(CL5_F6)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	591
OR655085	(CL1_S15)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	591
OR655093	(CL4_F10)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	593
OR655089	(CL3_S10)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	594
OR655088	(CL3_S6)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	599
OR655081	(CL5-F2)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	599
MN750015		AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	595
OR655080	(CL5-F1)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	600
OR655084	(CL1_S9)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	593
OR655095	(CL5_F11)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	591
OR655097	(RL1_S17)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	593
OR655099	(RL1_S33)	AGTTTGTCTGCTGTGGCATTAAATGGAGGAGTGTTCGATTTCGCGGTATGGTTGGCTTCGGC	597

OR655090	(CL4_F1)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	658
OR655091	(CL4_S4)	TGAACAGACGCTTATTAATATATCTTCAGCTGTGGAGGGATGAGTTGGTGAACCGTAGC	658
OR655082	(CL1_S2)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655100	(ChL4_S2)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655086	(CL2_S3)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	651
OR655096	(CL5_F12)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	654
OR655102	(RyL1_S19)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	652
OR655101	(RyL1_S12)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	652
OR655098	(RL1_S31)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	658
OR655083	(CL1_S5)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	652
OR655087	(CL2_S7)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655092	(CL4_S5)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	652
OR655094	(CL5_F6)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	651
OR655085	(CL1_S15)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	651
OR655093	(CL4_F10)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655089	(CL3_S10)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	654
OR655088	(CL3_S6)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	659
OR655081	(CL5-F2)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	659
MN750015		TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	655
OR655080	(CL5-F1)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	660
OR655084	(CL1_S9)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655095	(CL5_F11)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	651
OR655097	(RL1_S17)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	653
OR655099	(RL1_S33)	TGAACAGACGCTTATTAATATTTCTTCAGCTGTGGTGGTATGAGTTGGTGAACCGTAGC	657

OR655090	(CL4_F1)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	715
OR655091	(CL4_S4)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	718
OR655082	(CL1_S2)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655100	(ChL4_S2)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655086	(CL2_S3)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	711
OR655096	(CL5_F12)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	714
OR655102	(RyL1_S19)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	712
OR655101	(RyL1_S12)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	712
OR655098	(RL1_S31)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	718
OR655083	(CL1_S5)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	712
OR655087	(CL2_S7)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655092	(CL4_S5)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	712
OR655094	(CL5_F6)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	711
OR655085	(CL1_S15)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	711
OR655093	(CL4_F10)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655089	(CL3_S10)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	714
OR655088	(CL3_S6)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	719
OR655081	(CL5-F2)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	719
MN750015		TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	715
OR655080	(CL5-F1)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	720
OR655084	(CL1_S9)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655095	(CL5_F11)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	711
OR655097	(RL1_S17)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	713
OR655099	(RL1_S33)	TATGTGAGCTTGGCTTTTGAATTGGCTTTTGCTGTTGCGAAGTAGAGTGGC---GCTTCGCT	717

OR655090	(CL4_F1)	GTCGAGGGTCGATCCATTG-GGACTTGTGTATGCTTCGGCATGCATCTCATTGGACCTG	774
OR655091	(CL4_S4)	GTCGAGGGTCGATCCATTGGAAGTGTGTATGCTTCTTCATGCATCTCACTTGGACCT	778

OR655082	(CL1_S2)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655100	(ChL4_S2)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655086	(CL2_S3)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	771
OR655096	(CL5_F12)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	774
OR655102	(RyL1_S19)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	772
OR655101	(RyL1_S12)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	772
OR655098	(RL1_S31)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	778
OR655083	(CL1_S5)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	772
OR655087	(CL2_S7)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655092	(CL4_S5)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	772
OR655094	(CL5_F6)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	771
OR655085	(CL1_S15)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	771
OR655093	(CL4_F10)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655089	(CL3_S10)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	774
OR655088	(CL3_S6)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	779
OR655081	(CL5-F2)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	779
MN750015		GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	775
OR655080	(CL5-F1)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	780
OR655084	(CL1_S9)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655095	(CL5_F11)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	771
OR655097	(RL1_S17)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	773
OR655099	(RL1_S33)	GTCGAGGGTCGATCCATTTGGGAACCTTGTGTATGCTTCGGCATGCATCTCAATTGGACCT	777
***** * ***** * ***** * * *			
OR655090	(CL4_F1)	-ATATCAGC--AGATTACCCGCTGACTTAGCATATCATAGCCGGA----	816
OR655091	(CL4_S4)	GATATCAGGGAAGATTACACCCGTGACCTTGATCATATA-----	816
OR655082	(CL1_S2)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCATAGA-----	816
OR655100	(ChL4_S2)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATC-----	811
OR655086	(CL2_S3)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAA----	815
OR655096	(CL5_F12)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAA----	818
OR655102	(RyL1_S19)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACGGA--	819
OR655101	(RyL1_S12)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACGGA--	820
OR655098	(RL1_S31)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAC----	822
OR655083	(CL1_S5)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATA-----	814
OR655087	(CL2_S7)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACCC---	819
OR655092	(CL4_S5)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAAA-----	812
OR655094	(CL5_F6)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACCGGA-	819
OR655085	(CL1_S15)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAGG----	815
OR655093	(CL4_F10)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAAAAGGGA---	819
OR655089	(CL3_S10)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACCCGA-	822
OR655088	(CL3_S6)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAAAAACGGA--	826
OR655081	(CL5-F2)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAGGCCA--	826
MN750015		GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAGC----	820
OR655080	(CL5-F1)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAGCCAGA	829
OR655084	(CL1_S9)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAAA-----	813
OR655095	(CL5_F11)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAGGCC---	817
OR655097	(RL1_S17)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAAACGGA	822
OR655099	(RL1_S33)	GATATCAGGCAAGATTACCCGCTGAACCTAAGCATATCAATAACCGGA-	825
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Figure 3. Multiple sequence alignments of rDNA-ITS regions in *Phytophthora palmivora* isolates analyzed in this study. The accession number and isolate code are shown in the left of the column

3.2 Fungicide sensitivity

The sensitivity of all isolates of *Phytophthora* spp. to metalaxyl-M and dimethomorph was tested. The regression equation was used to estimate the 50% effective concentration (EC₅₀) to inhibit the mycelial growth of each isolate (Table 5). As shown in Table 4, in most of the tested locations, the pathogen population consisted of a mix of isolates with more than one fungicide sensitivity profile. In southern Thailand, 47 out of 81 isolates were resistant to metalaxyl-M, with an EC₅₀ of >100 mgL⁻¹. Only one isolate (CL1_S13) from CL1 was moderately resistant to metalaxyl-M with EC₅₀ 3.31 mgL⁻¹. Thirty-three isolates that were sensitive to metalaxyl-M. Met-M^R strains were detected in all locations in southern

Thailand. Moreover, strains that were sensitive to both metalaxyl-M and dimethomorph were detected in all surveyed provinces of south and eastern Thailand. In the east of Thailand, 5 of 60 isolates were resistant to metalaxyl-M with an $EC_{50} > 100 \text{ mgL}^{-1}$; 27 isolates were moderately resistant to metalaxyl-M with an $EC_{50} 1.15\text{-}89.93 \text{ mgL}^{-1}$, and 38 isolates were sensitive to metalaxyl-M. In the southern region, all isolates were sensitive to dimethomorph. In the eastern region, 9 out of 60 isolates were moderately resistant to dimethomorph with $1.07\text{-}2.71 \text{ mgL}^{-1}$, and 51 isolates were sensitive to dimethomorph with $EC_{50} < 1 \text{ mgL}^{-1}$ (Table 5).

Chemical fungicides are still crucial for controlling this pathogen and sustaining durian production in Thailand. Fungicides are sprayed frequently, at about 7-10-day intervals. Thus, monitoring fungicide resistance development in this pathogen is essential for guiding Thai durian farmers. These results indicate that the *P. palmivora* populations in Thailand are mainly sensitive to dimethomorph, while the population contains a mixture of metalaxyl-M-resistant, moderately resistant, and sensitive strains. However, several factors must be considered in interpreting results, such as the type of assays used and fungicide mode of action, especially in the absence of baseline sensitivity data. The results differed between the southern and eastern regions; isolates with resistance to metalaxyl-M were detected in all surveyed southern locations, while in the east region, most strains were sensitive or moderately resistant to metalaxyl-M. All strains were moderately resistant or sensitive to dimethomorph, with EC_{50} of $1\text{-}100 \text{ mgL}^{-1}$ and $EC_{50} < 1 \text{ mgL}^{-1}$, respectively. The detection of *P. palmivora* isolates with resistance to metalaxyl-M indicates that this fungicide might not offer effective control of *Phytophthora* diseases in durian. Previously, Kongtragoul et al. (2021) reported that in 2016-2017, *Phytophthora* spp. were resistant to metalaxyl in the same area of southern Thailand (metalaxyl is a racemic mixture, while metalaxyl-M is solely (97%) the R-enantiomer). Dimethomorph-resistant isolates of *P. palmivora* were not found in this study, although nine isolates were observed with moderate sensitivity. Dimethomorph was introduced more than 10 years ago and has been used to control durian diseases caused by *P. palmivora* without reports of resistance. On the FRAC pathogen risk list; Fungicide Resistance Action Committee (FRAC) (2022) classified the resistance risk of this fungicide as low to medium (Thanh et al., 2023). Although CAA-resistant isolates of *Plasmopara viticola* have been detected in the Europe zone, *P. infestans* is considered to have a low risk of developing such resistance.

In the durian orchards of south and eastern Thailand, phenylamides (PA) fungicides are sprayed approximately 2-4 times/month or more during the rainy season, creating a selection pressure for resistance to these fungicides. PA fungicides have been used in both regions for longer than dimethomorph, which may explain the higher number of strains with elevated metalaxyl-M EC_{50} values. The presence of strains of *P. palmivora* with moderate or high resistance to metalaxyl-M has been confirmed in southern and eastern Thailand durian orchards. We conclude that metalaxyl-M use should be considered carefully, as it could increase the management costs for durian production in Thailand if control is not fully effective. Metalaxyl-M should not be used for *Phytophthora* disease control in orchards where metalaxyl-resistant strains have already appeared and are widely distributed. However, in locations in which metalaxyl-sensitive strains are dominant, farmers should follow good resistance management practices, with the use of metalaxyl-M in disease management programs that include effective fungicides with other modes of action groups. Studies conducted over several years in *Phytophthora infestans* in European potato fields showed that during the epidemic phase of the disease cycle, the proportion of phenylamide-resistant strains increased, irrespective of whether the fields were treated with phenylamide fungicides (Abad et al., 2023). At the beginning of the next

Table 5. EC₅₀ values of *Phytophthora* spp. from southern in 2020 and earthen in 2020 and 2022 in response to metalaxyl-M and dimethomorph by mycelial growth assay

No.	Isolate code	Metalaxyl-M		Dimethomorph	
		EC ₅₀ (mg l ⁻¹)	Sensitivity Type	EC ₅₀ (mg l ⁻¹)	Sensitivity Type
2020, Southern					
1	CL1 S1	>100	R	0.28	S
2	CL1 S2	>100	R	0.32	S
3	CL1 S3	>100	R	0.34	S
4	CL1 S4	>100	R	0.28	S
5	CL1 S5	>100	R	0.42	S
6	CL1 S6	>100	R	0.33	S
7	CL1 S8	>100	R	0.30	S
8	CL1 S9	>100	R	0.44	S
9	CL1 S11	>100	R	0.60	S
10	CL1 S12	>100	R	0.37	S
11	CL1 S13	3.31	MR	0.41	S
12	CL1 S14	>100	R	0.50	S
13	CL1 S15	>100	R	0.11	S
14	CL2 S1	>100	R	0.16	S
15	CL2 S2	>100	R	0.28	S
16	CL2 S3	>100	R	0.23	S
17	CL2 S5	>100	R	<0.1	S
18	CL2 S7	>100	R	0.12	S
19	CL3 S1	0.20	S	0.22	S
20	CL3 S2	<0.1	S	0.15	S
21	CL3 S3	<0.1	S	0.36	S
22	CL3 S4	<0.1	S	0.24	S
23	CL3 S5	<0.1	S	0.47	S
24	CL3 S6	<0.1	S	0.19	S
25	CL3 S7	<0.1	S	0.41	S
26	CL3 S9	<0.1	S	0.27	S
27	CL3 S10	>100	R	0.40	S
28	CL3 S11	>100	R	0.35	S
29	CL4 F1	<0.1	S	0.39	S
30	CL4 F2	<0.1	S	0.33	S
31	CL4 S3	>100	R	0.39	S
32	CL4 S4	>100	R	0.32	S
33	CL4 S5	>100	R	0.88	S
34	CL4 F7	<0.1	S	0.31	S
35	CL4 F8	<0.1	S	0.30	S
36	CL4 F9	<0.1	S	0.51	S
37	CL4 F10	<0.1	S	0.35	S
38	CL5 F1	<0.1	S	0.35	S
39	CL5 F2	<0.1	S	0.35	S
40	CL5 F3	<0.1	S	0.26	S
41	CL5 F4	<0.1	S	0.22	S
42	CL5 F5	<0.1	S	0.25	S
43	CL5 F6	<0.1	S	0.21	S
44	CL5 F7	<0.1	S	0.38	S
45	CL5 F8	<0.1	S	0.51	S
46	CL5 F9	<0.1	S	0.54	S
47	CL5 F10	<0.1	S	0.46	S
48	CL5 F11	>100	R	0.58	S
49	CL5 F12	>100	R	0.33	S

Table 5. EC₅₀ values of *Phytophthora* spp. from southern in 2020 and earthen in 2020 and 2022 in response to metalaxyl-M and dimethomorph by mycelial growth assay (continued)

No.	Isolate code	Metalaxyl-M		Dimethomorph	
		EC ₅₀ (mg l ⁻¹)	Sensitivity Type	EC ₅₀ (mg l ⁻¹)	Sensitivity Type
50	CL5_F13	<0.1	S	0.32	S
51	CL6_S3	<0.1	S	<0.1	S
52	CL6_S51	>100	R	<0.1	S
53	CL6_S52	>100	R	<0.1	S
54	CL6_S53	>100	R	<0.1	S
55	CL6_S59	>100	R	<0.1	S
56	CL6_S60	>100	R	<0.1	S
57	CL6_S61	>100	R	<0.1	S
58	SL1_S4	>100	R	0.23	S
59	SL1_S6	>100	R	0.28	S
60	SL1_S8	>100	R	0.30	S
61	SL1_S20	0.66	S	0.23	S
62	SL1_S27	<0.1	S	0.15	S
63	SL1_S29	<0.1	S	<0.1	S
64	SL1_S30	<0.1	S	<0.1	S
65	SL1_B101	<0.1	S	0.28	S
66	SL2_S2	>100	R	0.41	S
67	SL2_S5	>100	R	0.23	S
68	SL2_S7	<0.1	S	0.32	S
69	SL2_S8	>100	R	<0.1	S
70	SL2_S18	>100	R	<0.1	S
71	RL1_S16	>100	R	0.57	S
72	RL1_S17	>100	R	0.75	S
73	RL1_S30	>100	R	0.55	S
74	RL1_S31	>100	R	0.37	S
75	RL1_S33	>100	R	<0.1	S
76	RL2_S1	<0.1	S	<0.1	S
77	RL2_S2	>100	R	<0.1	S
78	RL2_S4	>100	R	<0.1	S
79	RL2_S5	>100	R	<0.1	S
80	RL2_S10	>100	R	<0.1	S
81	RL2_S15	>100	R	<0.1	S
2020, Eastern					
1	ChL4_S2	36.6	MR	0.41	S
2	RYL1_S12	<0.1	S	<0.1	S
3	RYL1_S18	0.10	S	0.54	S
4	RYL1_S19	<0.1	S	0.16	S
5	RYL1_S20	<0.1	S	0.16	S
6	RYL1_S30	0.17	S	0.72	S
2022, Eastern					
1	Chl1_S1	2.89	MR	<0.10	S
2	Chl1_S2	3.65	MR	<0.10	S
3	Chl1_S3	2.19	MR	<0.10	S
4	Chl1_S4	2.00	MR	<0.10	S
5	Chl1_S5	1.46	MR	<0.10	S
6	Chl1_S6	1.21	MR	<0.10	S
7	Chl2_F1	4.45	MR	0.60	S

Table 5. EC₅₀ values of *Phytophthora* spp. from southern in 2020 and earthen in 2020 and 2022 in response to metalaxyl-M and dimethomorph by mycelial growth assay (continued)

No.	Isolate code	Metalaxyl-M		Dimethomorph	
		EC ₅₀ (mg l ⁻¹)	Sensitivity Type	EC ₅₀ (mg l ⁻¹)	Sensitivity Type
8	ChI2_F2	5.69	MR	0.60	S
9	ChI2_F3	4.85	MR	0.38	S
10	ChI2_F4	6.49	MR	0.25	S
11	ChI2_F5	2.73	MR	0.14	S
12	ChI2_F6	2.34	MR	0.90	S
13	ChI3_F1	3.88	MR	0.42	S
14	ChI3_F2	3.19	MR	0.39	S
15	ChI3_F3	0.64	S	0.40	S
16	ChI3_F4	1.15	MR	0.48	S
17	ChI3_F5	0.85	S	0.25	S
18	ChI3_F6	0.67	S	0.55	S
19	ChI4_F1	>100	R	0.87	S
20	ChI4_F2	89.93	MR	1.38	MR
21	ChI4_F3	>100	R	0.83	S
22	ChI4_F4	>100	R	0.96	S
23	ChI4_F5	>100	R	1.15	MR
24	ChI4_F6	>100	R	0.77	S
25	ChI5_F1	0.55	S	0.66	S
26	ChI5_F2	2.30	MR	0.88	S
27	ChI5_F3	0.64	S	0.63	S
28	ChI5_F4	<0.1	S	<0.10	S
29	ChI5_F5	0.99	S	0.94	S
30	ChI5_F6	2.09	MR	0.86	S
31	ChI6_F1	0.20	S	<0.10	S
32	ChI6_F2	<0.10	S	<0.10	S
33	ChI6_F3	2.06	MR	1.67	MR
34	ChI6_F4	2.99	MR	1.99	MR
35	ChI6_F5	<0.10	S	<0.10	S
36	ChI6_F6	<0.10	S	<0.10	S
37	TrL1_F1	0.57	S	0.24	S
38	TrL1_F2	0.84	S	1.19	MR
39	TrL1_F3	0.22	S	0.35	S
40	TrL1_F4	0.35	S	0.43	S
41	TrL1_F5	0.67	S	0.35	S
42	TrL1_F6	0.54	S	0.37	S
43	TrL2_F1	0.87	S	0.84	S
44	TrL2_F2	0.94	S	0.86	S
45	TrL2_F3	0.93	S	0.99	S
46	TrL2_F4	0.93	S	1.07	MR
47	TrL2_F5	0.88	S	1.40	MR
48	TrL2_F6	0.84	S	0.90	S
49	RyL2_S1	1.28	MR	0.96	S
50	RyL2_S2	1.50	MR	0.94	S
51	RyL2_S3	1.20	MR	0.92	S
52	RyL2_S4	1.50	MR	0.95	S
53	RyL2_S5	2.98	MR	2.71	MR
54	RyL2_S6	2.08	MR	1.75	MR

season, the proportion of phenylamine-resistant strains declined. These observations suggest that resistant isolates have a higher fitness during the epidemic phase but survive less well between seasons. Based on these findings, and considering the high systemicity of phenylamide fungicides, the FRAC recommends that they are applied in the early season or during the period of active growth of the crop for best efficacy. Although population dynamics have not been studied as extensively in other *Phytophthora* species, sensitivity monitoring has often revealed a mixture of resistant, intermediate, and sensitive strains. In such scenarios, metalaxyl-M would still be expected to provide significant fungicidal efficacy by controlling the sensitive or intermediate strains.

In contrast, populations of *P. palmivora* are still sensitive to dimethomorph, which suggests that the fungicides would give good efficacy in the surveyed areas for the time being. However, durian growers should use dimethomorph in mixture or alternation with fungicides from other mode of action groups in an integrated disease management program because the occurrence of moderately resistant strains to dimethomorph also provides an early warning of the risk of resistance development. Further studies are necessary to monitor fungicide resistance in a broader range of pathogen populations in Thailand.

4. Conclusions

A total of 141 *Phytophthora* isolates were isolated from symptomatic tissue of root, stem, and root rot of durian diseases from twenty orchards in southern and eastern Thailand. The pathogens were identified by morphology and nucleotide sequences as *P. palmivora*. Our findings confirmed the emerging fungicide resistance in populations of *P. palmivora* in both regions. The resistance to metalaxyl-M occurred in both the southern and eastern regions. All southern isolates were sensitive (S) to dimethomorph. However, MR and S isolates to dimethomorph were found in the eastern region.

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6. Author Contributions

Conceptualization: P.K., S.R. and S.K.; Methodology: P.K., S.R., and S.K.; Software: P.K.; validation, P.K., S.R., and S.K.; Formal analysis: P.K., S.R., and S.K.; Investigation: P.K., S.R., and S.K.; P.K., S.R., and S.K.; Data curation: P.K., S.R., and S.K.; Writing—original draft preparation: P.K.; Writing—review: P.K.; Editing: S.R. and S.K.; Visualization: S.K.; Supervision: S.K.; Project administration: P.K.; Funding acquisition: P.K., S.R. and S.K. All authors have read and agreed to the published version of the manuscript.

7. Conflicts of Interest

The authors declare no conflict of interest.

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