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# Molecular signatures (conserved indels) in protein sequences that are specific for the order Pasteurellales and distinguish two of its main clades

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Abstract The members of the order Pasteurellales are currently distinguished primarily on the basis of their branching in the rRNA trees and no convincing biochemical or molecular markers are known that distinguish them from all other bacteria. The genome sequences for 20 Pasteurellaceae species/strains are now publicly available. We report here detailed analyses of protein sequences from these genomes to identify conserved signature indels (CSIs) that are specific for either all Pasteurellales or its major clades. We describe more than 23 CSIs in widely distributed genes/proteins that are uniquely shared by all sequenced Pasteurellaceae species/strains but are not found in any other bacteria. Twenty-one additional CSIs are also specific for the Pasteurellales except in some of these cases homologues were not detected in a few species or the CSI was also present in an isolated non-Pasteurellaceae species. The sequenced Pasteurellaceae species formed two distinct clades in a phylogenetic tree based upon concatenated sequences for 10 conserved proteins. The first of these clades consisting of Aggregatibacter, Pasteurella, Actinobacillus succinogenes, Mannheimia

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H. S. Naushad · R. S. Gupta (⊠) Department of Biochemistry and Biomedical Sciences, McMaster University, Hamilton, ON L8N 3Z5, Canada e-mail: gupta@mcmaster.ca succiniciproducens, Haemophilus influenzae and Haemophilus somnus was also independently supported by 13 uniquely shared CSIs that are not present in other Pasteurellaceae species or other bacteria. Another clade consisting of the remaining Pasteurellaceae species (viz. Actinobacillus pleuropneumoniae, Actinobacillus minor, Haemophilus ducryi, Mannheimia haemolytica and Haemophilus parasuis) was also strongly and independently supported by nine CSIs that are uniquely present in these bacteria. The order Pasteurellales is presently made up of a single family, Pasteurellaceae, that encompasses all of its genera. In this context, our identification of two distinct clades within the Pasteurellales, which are supported by both phylogenetic analyses and by multiple highly specific molecular markers, strongly argues for and provides potential means for the division of various genera from this order into a minimum of two families. The genetic changes responsible for these CSIs were likely introduced in the common ancestors of either all Pasteurellales or of these two specific clades. These CSIs provide novel means for the identification and circumscription of these groups of Pasteurellales in molecular terms.

**Keywords** Conserved indels · Pasteurellales taxonomy and systematics · Pasteurellales clades · Phylogenetic analyses · *Pasteurellaceae* genomes · Comparative genomics · Molecular markers for Pasteurellales · Lateral gene transfers

Table 1 Sequence characteristics of the Pasteurellales get	nomes
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Organism	GenBank accession No.	Size (Mbp)	No. of proteins	% GC content	Reference
Actinobacillus pleuropneumoniae L20	CP000569	2.3	2012	41.3	Foote et al. (2008)
Actinobacillus pleuropneumoniae serovar 3 str. JL03	CP000687	2.2	2036	41.2	Xu et al. (2008)
Actinobacillus pleuropneumoniae serovar 7 str. AP76	CP001091	2.3	2131	41.2	STHH <sup>b</sup>
Actinobacillus succinogenes 130Z	CP000746	2.3	2079	44.9	DOE-JGI
Actinobacillus minor 202	ACFT00000000	2.1	2050	39.3	McGill University <sup>c</sup>
Aggregatibacter actinomycetemcomitans D11S-1	CP001733	2.2	2135	44.3	Chen et al. (2009)
Aggregatibacter aphrophilus NJ8700	CP001607	2.3	2219	42.2	Di Bonaventura et al. (2009) <sup>c</sup>
Haemophilus ducreyi 35000HP	AE017143	1.7	1717	38.2	Ohio State University <sup>a</sup>
Haemophilus influenzae 86-028NP	CP000057	1.9	1792	38.2	Harrison et al. (2005)
Haemophilus influenzae PittEE	CP000671	1.8	1613	38.0	Hogg et al. (2007)
Haemophilus influenzae PittGG	CP000672	1.9	1661	38.0	Hogg et al. (2007)
Haemophilus influenzae Rd KW20	L42023	1.8	1657	38.2	Fleischmann et al. (1995)
Haemophilus influenzae R2846	CP002276	1.8	1691	38.0	UW-BRI
Haemophilus influenzae R2866	CP002277	1.9	1817	38.1	UW-BRI
Haemophilus parasuis SH0165	CP001321	2.3	2021	40.0	Yue et al. (2009)
Haemophilus somnus 129PT	CP000436	2.0	1792	37.2	Barabote et al. (2009)
Haemophilus somnus 2336	CP000947	2.3	1980	37.4	Virginia Tech
Mannheimia haemolytica <sup>c</sup>	AASA01000000	2.6	2839	41.1	Gioia et al. (2006)
Mannheimia succiniciproducens MBEL55E	AE016827	2.3	2369	42.5	Hong et al. (2004)
Pasteurella multocida subsp. multocida str. Pm70	AE004439	2.3	2015	40.4	May et al. (2001)

UW-BRI University of Washington; Seattle Biomedical Research Institute, DOE-JGI Genome is sequenced by the Department of Education Joint Genome Institute

<sup>a</sup> Sequenced by Ohio State University

<sup>b</sup> Sequenced by Stiftung Tieraerztliche Hochschule Hannover (STHH)

<sup>c</sup> Draft genomes. The sequences for Actinobacillus minor 202 and NM305 are being sequenced by McGill University

# Introduction

The members of the order Pasteurellales are Gramnegative, non-motile and aerobic to facultative anaerobic bacteria, which constitute one of the main orders within the Class Gammaproteobacteria (Pohl 1981; Mutters et al. 1989; Paster et al. 1993; Olsen et al. 2005; Christensen et al. 2007; Christensen and Bisgaard 2010). The order Pasteurellales presently contains a single family, *Pasteurellaceae*, that is made up of at least 15 genera and >70 species (see http://www.the-icsp.org/taxa/Pasteurellaceaelist.htm; Christensen and Bisgaard 2010). These bacteria are commonly present as commensals in the mucosal membranes of the respiratory, alimentary and reproductive tracts of various vertebrates (mainly birds and mammals) including humans (Bisgaard 1993; Olsen et al. 2005; Christensen and Bisgaard 2010). The presence of these bacteria in both healthy as well as diseased vertebrates indicates that they are opportunistic pathogens and several of them are important human and animal pathogens. For example, *Hae-mophilus influenzae, Haemophilus ducreyi* and *Aggregatibacter* (*Agg.*) actinomycetemcomitans are respectively involved in the causation of bacteremia, pneumonia and acute bacterial meningitis; the sexually transmitted disease chancroid; and juvenile periodontitis in humans (Bisgaard 1993; Fleischmann et al. 1995; Spinola et al. 2002; Olsen et al. 2005; Christensen and Bisgaard 2010). Other species such as *Mannheimia (Man.) haemolytica, Pasteurella multocida* and *Actinobacillus (Act.) pleuropneumoniae* are causative agents of the shipping fever in cattle, fowl cholera and pleuropneumonia in pigs, respectively (Bisgaard 1993; Bosse et al. 2002; Gioia et al. 2006).

The Pasteurellales are presently distinguished from other bacteria primarily on the basis of their branching in 16S rRNA gene sequence trees, where they form a distinct cluster (Mutters et al. 1989; De Ley et al. 1990; Dewhirst et al. 1992; Dewhirst et al. 1993; Olsen et al. 2005; Christensen and Bisgaard, 2006; Christensen and Bisgaard, 2010). The species from this order/family also form a distinct clade in phylogenetic trees based on numerous other genes and protein sequences (Korczak et al. 2004; Christensen et al. 2004; Kuhnert and Korczak, 2006; Gao et al. 2009; Williams et al. 2010). Some morphological and nutritional characteristics such as lack of motility, requirement for sodium ions, V-factor and organic nitrogen sources for growth, are often used to distinguish these bacteria from other orders of Gammaproteobacteria (e.g. Vibrionales, Aeromonadales, Enterobacteriales and Alteromonadales) (Olsen 1993; Kainz et al. 2000; Olsen et al. 2005; Christensen and Bisgaard 2006; Hayashimoto et al. 2007). However, none of these characteristics are unique for the Pasteurellales and reliance only on them can lead to incorrect identification/placement of species in this group and its various genera (Christensen et al. 2004; Olsen et al. 2005; Christensen et al. 2007; Christensen and Bisgaard 2010). Presently, no convincing molecular or biochemical characteristic is known that is uniquely shared by various Pasteurellales and which can be used to clearly distinguish this group of bacteria from all others. Our current understanding of the phylogeny/taxonomy for these bacteria is also unsatisfactory (Olsen et al. 2005; Christensen and Bisgaard 2006). For example, several of the genera classified within Pasteurellales (viz. Haemophilus, Actinobacillus and Mannheimia) are not monophyletic and species from them branch in a number of different clusters with other members of this group (Olsen et al. 2005; Gioia et al. 2006; Redfield et al. 2006; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010; Bonaventura et al. 2010). Although suggestions have been made to restrict these genera to a limited number of species (Olsen et al. 2005; Christensen and Bisgaard 2006), the taxonomy of members of the Pasteurellales/*Pasteurellaceae* is clearly unsatisfactory at present (Christensen et al. 2007; Christensen and Bisgaard, 2010; Bonaventura et al. 2010). Thus, it is important to identify other novel sequence based characteristics that could provide reliable means for the identification of species from this order and which could also prove useful in clarifying their taxonomy and evolutionary relationships.

Since the sequencing of first genome for H. influenzae in 1995 (Fleischmann et al. 1995), sequence data for more than 1500 bacteria covering all major bacterial phyla are now available (http://www.ncbi. nlm.nih.gov/PMGifs/Genomes/micr.html). Of these genomes, 20 genomes are from Pasteurellales species/ strains representing five genera from this family (Table 1). These genome sequences provide an unprecedented and valuable resource for discovering novel molecular characteristics that are uniquely shared by either all Pasteurellales or specific groups/ clades of these bacteria and could provide more reliable means for their identification (Shah et al. 2009). Using genomic sequences, our recent work has focused on identifying two different types of molecular markers that are specific for different groups of bacteria. One type of molecular markers consists of conserved signature inserts or deletions (i.e. Indels) (CSIs) in widely distributed proteins, that are specifically present in particular groups of bacteria (Gupta 2000; Gupta and Mok 2007; Gupta 2009; Gupta 2010). The whole proteins that are uniquely present in particular groups of bacteria provide another type of molecular markers that are useful for these studies (Gupta 2006; Gupta and Griffiths 2006; Gupta and Mathews 2010). Our recent work has identified large numbers of CSIs for a number of major taxa within bacteria (viz. Alphaproteobacteria, Epsilonproteobacteria, Chlamydiae, Actinobacteria, Cyanobacteria, Bacteroidetes-Chlorobi, Deinococcus-Thermus) and for many of their subgroups (Gupta and Griffiths 2006; Gupta and Mathews 2010). Recently, some molecular signatures for the Class Gammaproteobacteria as a whole were also identified (Gao et al. 2009).

In the present work, we have employed these comparative genomic approaches in conjunction with phylogenetic analysis for investigation of the

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Protein name	Gene name	Accession no.	Figure nos.	Indel size	Indel position <sup>a</sup>	Functional categories
Tetratricopeptide domain protein	-	YP_003006869	Fig. 2a	8 aa ins	44–91	Carbohydrate transport and metabolism
Murein transglycosylase C	mltC	YP_001343852	Supplementary Fig. 1	3 aa del	76–116	Cell wall/membrane biogenesis
Exoribonuclease II	rnb	NP_873703	Supplementary Fig. 2	10 aa ins	416–468	Transcription
Glycerol-3-phosphate acyltransferase	plsB	YP_003255015	Supplementary Fig. 3	2 aa ins	554–610	Lipid transport and metabolism
3-phosphoshikimate 1-carboxyvinyltransferase	aroA	YP_003256375	Supplementary Fig. 4	2 aa ins	360-402	Amino acid transport and metabolism
Hypothetical protein CGSHiEE_05875	-	YP_001290919	Supplementary Fig. 5	2 aa ins	32–71	General function prediction only
5-methylaminomethyl-2- thiouridine methyltransferase	mnmC	YP_003255458	Supplementary Fig. 6	2 aa del	122–152	Multifunctional
Adenylate cyclase <sup>b</sup>	cyaA	NP_873154	Supplementary Fig. 7	2 aa del	526–576	Nucleotide transport and metabolism
Murein transglycosylase A	mltA	NP_874023	Supplementary Fig. 8	1 aa del	241–286	Cell wall/membrane biogenesis
Lipoyltransferase	lipB	YP_001344010	Supplementary Fig. 9	1–5 aa ins	75–116	Coenzyme transport and metabolism
Transcription repair coupling factor	mfd	NP_873467	Supplementary Fig. 10A	1 aa ins	226-261	Replication, recombination and repair
Fumarate reductase flavoprotein subunit	frdA	NP_872657	Supplementary Fig. 10B	1 aa ins	287–331	Energy production and conversion
Hemolysin	corB	YP_003008000	Supplementary Fig. 11	1 aa ins	228-270	Inorganic ion transport and metabolism
Chaperonin HslO	hslO	ZP_05919977	Supplementary Fig. 12	1 aa ins	246–278	Posttranslational modification, protein turnover and chaperones
Exodeoxyribonuclease VII small subunit	xseB	ZP_01791820	Supplementary Fig. 13	1 aa ins	27–68	Replication, recombination and repair
Periplasmic serine peptidase DegS	degS	ZP_05850718	Supplementary Fig. 14	1 aa ins	190–216	Posttranslational modification, protein turnover and chaperones
Multidrug resistance protein MdtK	mdtK	YP_003007368	Supplementary Fig. 15	1 aa ins	200–249	Defense mechanisms
Glutamate-ammonia-ligase adenylyltransferase	glnE	YP_088470	Supplementary Fig. 16	1 aa ins	271-309	Multifunctional
Hypothetical protein PM0734	-	NP_245671	Supplementary Fig. 17	1 aa ins	184–212	Hypothetical
Hypothetical protein HD1793	-	NP_874155	Supplementary Fig. 18	1 aa ins	168–200	Hypothetical
Hypothetical protein HD1794	-	NP_874156	Supplementary Fig. 19	1 aa ins	75–109	Hypothetical
Peptidyl-prolyl cis-trans isomerase B	ppiB	ZP_06222848	Supplementary Fig. 20	6 aa ins	43–75	Posttranslational modification, protein turnover and chaperones

Table 2 Conserved Signature Indels that are specific for all Pasteurellales

#### Table 2 continued

Protein name	Gene name	Accession no.	Figure nos.	Indel size	Indel position <sup>a</sup>	Functional categories
Peptidyl-prolyl cis–trans isomerase B	ppiB	YP_003007916	Supplementary Fig. 21	6 aa ins	100–137	Posttranslational modification, protein turnover and chaperones
Nicotinamide-nucleotide adenylyltransferase <sup>c</sup>	nadR	YP_003255205	Supplementary Fig. 22	1 aa ins	121–151	Coenzyme transport and metabolism
<i>N</i> -acetyl-D-glucosamine kinase (GlcNAc kinase) <sup>c</sup>	nagK	YP_003007117	Supplementary Fig. 23	1 aa ins	153–195	Multifunctional
Putative inner membrane protein <sup>c</sup>	-	ZP_02478497	Supplementary Fig. 24	1 aa ins	197–222	Cell wall/membrane
Galactokinase <sup>c</sup>	galK	YP_003007703	Supplementary Fig. 25	3 aa ins	240–276	Carbohydrate transport and metabolism
Deoxyguanosinetriphosphate triphosphohydrolase-like protein <sup>c</sup>	_	YP_001344904	Supplementary Fig. 26	17 aa ins	59–126	Nucleotide transport and metabolism
Inner membrane protein YicO <sup>c</sup>	yicO	YP_003007341	Supplementary Fig. 27	1 aa ins	199–237	General function prediction only
PTS system, fructose subfamily, IIC subunit <sup>c</sup>	fruA	YP_001343401	Supplementary Fig. 28	3 aa ins	241-281	Carbohydrate transport and metabolism
Anion transporter <sup>c</sup>	-	YP_001343337	Supplementary Fig. 29	7 aa ins	258–296	Inorganic ion transport and metabolism
Hypothetical protein PM0935 <sup>c</sup>	-	NP_245872	Supplementary Fig. 30	4 aa ins	61–108	Hypothetical
23S rRNA (guanosine-2'- <i>O</i> -)- methyltransferase <sup>d</sup>	rlmB	ZP_05629947	Supplementary Fig. 31	1 aa ins	115–178	Posttranslational modification, protein turnover, chaperones
Glutamate ammonia ligase adenylyltransferase <sup>d</sup>	glnE	NP_874080	Supplementary Fig. 32	17 aa ins	381–436	Multifunctional
Murein transglycosylase C <sup>d</sup>	mltC	YP_001343852	Supplementary Fig. 33	1 aa ins	148–180	Cell wall/membrane biogenesis
ProS protein <sup>d</sup>	proS	AAU38670	Supplementary Fig. 34	1 aa ins	453–482	Translation
D-methionine-binding lipoprotein <sup>d</sup>	metQ	YP_003008527	Supplementary Fig. 35	1 aa ins	97–130	Inorganic ion transport and metabolism
DNA-dependent helicase II <sup>e</sup>	uvrD	YP_001293092	Fig. 2B	3–4 aa ins	61–104	Replication, recombination and repair
Hypothetical protein NT05HA_0747 <sup>e</sup>	-	YP_003007227	Supplementary Fig. 36A	2 aa ins	36–68	Unknown
Lysyl-tRNA synthetase <sup>e</sup>	genX	NP_245139	Supplementary Fig. 36B	2 aa del	148–191	Translation
Protein cof <sup>e</sup>	-	YP_003008147	Supplementary Fig. 37	1 aa ins	45-80	General function prediction only
6-phosphogluconolactonase <sup>e</sup>	pgl	NP_873341	Supplementary Fig. 38	4 aa del	97–145	Carbohydrate transport and metabolism
Geranyltranstransferase <sup>e</sup>	ispA	ZP_04977790	Supplementary Fig. 39	2 aa del	112–150	Coenzyme transport and metabolism

Protein name	Gene name	Accession no.	Figure nos.	Indel size	Indel position <sup>a</sup>	Functional categories
DNA repair protein RecN <sup>e</sup>	recN	YP_002475883	Supplementary Fig. 40	3 aa ins	68–106	Replication, recombination and repair
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<sup>a</sup> The indel position indicates the region of the protein where a given CSI is present

<sup>b</sup> A 1 aa deletion is present in *H. parasuis* rather than the 2 aa deletion found in all Pasteurellales

<sup>c</sup> Homologous sequences corresponding to this region were not identified in some Pasteurellales species

<sup>d</sup> The CSI is not present in 1-2 Pasteurellales species

e The CSI is also found in 1-2 non-Pasteurellales species

available Pasteurellales genomes. The primary objective of this work is to identify novel molecular markers consisting of conserved signature indels (CSIs) that are unique to either all Pasteurellales or its major subgroups/clades. Our work has identified >40 CSIs that are specific for all (or most) genome sequenced Pasteurellales species/strains. In addition, we also describe many CSIs that are specific for a number of distinct subclades of Pasteurellales, which are also supported by phylogenetic analyses. These molecular signatures provide valuable means for the identification of members of the Pasteurellales and a number of their subclades and for the division of Pasteurellales into two distinct groups.

## Methods

#### Phylogenetic analysis

Phylogenetic analysis was performed on a concatenated sequence alignment for 10 highly conserved proteins (viz. 50S ribosomal protein L5, RNA polymerase subunit beta (RpoB), prolyl-tRNA synthetase, chaperone protein DnaK, threonyl-tRNA synthetase, valyl-tRNA synthetase, cell division protein FtsY, alanyl-tRNA synthetase, translation initiation factor IF-2, DNA gyrase subunit B) that are present in most extant bacteria (Harris et al. 2003) and which have been extensively used for phylogenetic studies (Korczak et al. 2004; Christensen et al. 2004; Gao et al. 2009; Gupta 2009). The sequences for these proteins for various Pasteurellales and several other Gammaproteobacteria, which served as outgroup, were retrieved and multiple sequence alignments for them were created using the CLUSTAL\_X 1.83 program (Jeanmougin et al. 1998). After concatenation, the poorly aligned regions from the sequence alignment were removed using the Gblocks 0.91b program (Castresana 2000). The resulting alignment, which consisted of 6783 characters, was employed for phylogenetic analyses. A neighbour-joining (NJ) tree based upon 500 bootstrap replicates of this sequence alignment was constructed employing Kimura's distance calculation using the TREECON 1.3 program (Van de Peer and De Wachter 1994).

Identification of CSIs for members of the order Pasteurellales

To identify conserved indels in protein sequences that might be specific for the Pasteurellales, Blastp searches were performed on all proteins from the genome of Aggregatibacter aphrophilus NJ8700 (Di Bonaventura et al. 2009). For those proteins/ORFs for whom high scoring homologues were present in most Pasteurellales species/strains as well as certain outgroup species, sequences for 10-15 high scoring homologues were retrieved from diverse Pasteurellales and other bacteria and their multiple sequence alignments were constructed using the Clustal X 1.83 program. These sequence alignments were visually inspected to identify any conserved inserts or deletions that were restricted to either all Pasteurellales or its major clades and which were flanked by at least 5-6 identical/conserved residues in the neighboring 30-40 amino acids on each side. The indels that were not flanked by conserved regions were not further studied as they do not provide useful molecular markers (Gupta 1998; Gupta 2000; Gupta 2009). The conserved indels, which in addition to the Fig. 1 A neighbor-joining distance tree for the sequenced Pasteurellales based upon concatenated sequences for 10 conserved proteins. The tree was rooted using sequences for other Gammaproteobacteria (viz. Vibrionales or Enterobacteriales) and the numbers on the nodes indicate the bootstrap values out of 500. The two main clades of Pasteurellales that are seen in the tree are marked



Pasteurellales were also present in a few other bacteria, were also retained. The indels for individual species or smaller clades were not analyzed in detail in the present work. The species distribution patterns of all such indels were further evaluated by detailed Blastp searches on short sequence segments containing the indels and their flanking conserved regions (Gupta 2009). The sequence information for various conserved indels from all Pasteurellales and some representative high scoring Gammaproteobacteria were compiled into signature files. Due to space consideration, sequence information for different strains of the same species is not shown, but the indicated CSIs were present in all of the sequenced strains. Further, unless otherwise noted, all of these CSIs are specific for the indicated groups.

## Results

## Phylogenetic analysis of Pasteurellales

The evolutionary relationships among Pasteurellales in the past was mainly examined on the basis of phylogenetic trees for the 16S rRNA gene and a number of individual protein sequences (Dewhirst et al. 1993; Korczak et al. 2004; Christensen et al. 2004; Olsen et al. 2005; Christensen and Bisgaard 2006). However, the availability of genome sequences now enables one to determine the branching order of these species based upon concatenated sequences for large numbers of proteins. The trees based upon large numbers of characters derived from multiple proteins provide more reliable indication of the phylogenetic relationships within a given group than those based on any single gene or protein (Rokas et al. 2003; Ciccarelli et al. 2006; Gao et al. 2009; Wu et al. 2009; Williams et al. 2010). Previously, Redfield et al. (2006) and Gioia et. al. (2006) have reported construction of phylogenetic trees for eight Pasteurellales species (viz. H. influenzae, H. ducreyi, Haemophilus somnus, P. multocida, Act. pleuropneumoniae, Agg. actinomycetemcomitans, Mannheimia succiniciproducens and Man. haemolytica, based upon concatenated sequences for 12 and 50 conserved proteins, respectively. More recently, Bonaventura et al. (Bonaventura et al. 2010) have carried out detailed phylogenetic analyses for 12 Pasteurellales genomes representing 10 species (the above eight species plus Agg. aphrophilus and Actinobacillus succinogens) based upon concatenated sequences for different orthologous proteins found in their genomes. Although, these trees provide useful resources for understanding the evolutionary relationships among the indicated Pasteurellaceae species/ strains, in the past 2-3 years sequences for a number of new Pasteurellaceae species (viz. Haemophilus parasuis, Actinobacillus minor and Pasteurella dagmatis), as well as additional strains for several species, have become available in the NCBI database (Table 1). A few characteristics of these genomes, some of which are draft genomes, are listed in Table 1. In order to determine the evolutionary significances of various CSIs identified by our analyses, it was necessary to construct a phylogenetic tree that included sequence information for all of these Pasteurellales. In the present work, phylogenetic trees for 20 Pasteurellales species/strains representing 13 species were constructed based upon concatenated sequences for 10 conserved proteins.

A NJ distance tree for the above Pasteurellales species that was rooted using other Gammaproteobacteria (viz. Vibrionales or Aeromonadales) is shown in Fig. 1. As expected, the Pasteurellales species formed a distinct and strongly supported clade in the tree. Further, as observed in earlier studies, species from a number of Pasteurellales genera viz. Haemophilus, Actinobacillus and Mannheimia branched in a number of different clusters, indicating that these genera are not monophyletic. In the NJ tree shown, the Pasteurellales species formed two main clades. The first of these clades (Clade I) consists of various Aggregatibacter and Pasteurella species and it also included Act. succinogenes, Man. succiniciproducens and various strains of H. influenzae and H. somnus. Within this clade, the grouping of Aggregatibacter with Pasteurella species and that of Act. succinogenes with Man. succiniciproducens was strongly supported. The second clade (Clade II) consisted of H. ducryi, H. parasuis, Man. haemolytica and various strains of Act. pleuropneumoniae. These two clades of Pasteurellales were also supported by earlier phylogenetic studies based upon different datasets of protein sequences (Gioia et al. 2006; Redfield et al. 2006; Bonaventura et al. 2010). These trees provide us a phylogenetic framework to understand/interpret the evolutionary significance of various identified CSIs.

Fig. 2 Partial sequence alignments of the proteins a a tetratricopeptide domain-containing protein showing a conserved CSI (boxed) that is uniquely present in all Pasteurellales species and b DNA-dependent helicase II, showing a conserved insert (boxed) that is largely specific for all Pasteurellales. However, in this case the CSI was also present in one non-Pasteurellales species (marked with arrow). The shared presence of the CSI in this species could be due to LGTs, however, other possibilities cannot be excluded. The dashes in the sequence alignments indicate identity with the amino acid on the top line. The numbers on the top lines indicate the regions of proteins where these CSIs are present in the species shown on the top. Sequence information for other bacteria is shown here for only a limited number of species. However, no other species within the first 500 blast hits contained the indicated indels. Information for many other CSIs that are specific for all Pasteurellales is provided in Table 2

Identification of conserved indels that are specific for the order Pasteurellales

Our analyses have identified 44 CSIs in broadly distributed proteins that are largely specific for most of the sequenced Pasteurellales species (Table 2). The CSIs in the first 23 proteins listed in this table are commonly shared by all sequenced Pasteurellales species/strains but they are not found in the homologues from any other bacteria (at least the top 500 blast hits). One example of these Pasteurellalesspecific CSIs is shown in Fig. 2a. In this case, an 8 aa insert in a highly conserved region of a tetratricopeptide (TPR) domain-containing protein is uniquely present in all sequenced Pasteurellales. Although, sequence information is presented here for only a limited number of species, unless indicated otherwise, the CSI shown here as well as other molecular signatures shown are specific for the Pasteurellales group and not found elsewhere. Other CSIs that are uniquely present in all Pasteurellales are listed in Table 2 and the sequence alignments of these proteins showing the presence of the indicated CSIs are provided as Supplementary Figs. 1-21. Of these, the enzyme peptidyl-prolyl cis-tran isomerase B contains two 6 aa inserts in different positions that are specifically present in all sequenced Pasteurellales. However, there are two homologues of this protein in P. multocida, P. dagmatis and Man. succiniciproducens and these CSI are present in only one of the homologues (Supplementary Figs. 20, 21). Five other proteins listed in Table 2 (Supplementary Figs. 22-26), also contain CSIs that are specific for the Pasteurellaceae species. However, the homologues

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	Agg. aphrophilus	251792149	NELLANQTEKAVDLELDMLQ	QENENEI DSNSQFEAELTLGNLFRSRG
(A) .		261868285		
	Agg. actinomycetemcomitans	201000203		
	ACT. MINOP	257464684		
	Act. succinogenes	152979209	····\$-···· -	A  EQS
	Act. pleuropneumoniae	165976153	SQS -	AQ- ATE
	Haemophilus ducreyi	33152427	SQS	
Pasteurellales	Haemophilus influenzae	68250245	SD	I E-H I
(20/20)	Haemonhilus narasuis	219870698		S. O. STE.
(20/20)	Hacmophilus parasais	110461116		
	Haemophilius somnus	113401110	-L3HA1	
	Man. Haemolytica	254361240	····s··q····s··· ·	SH- A-E
	Man. succiniciproducens	52425528	SH -	• • • E • • • •   • • • • • • • • • • •
	Pasteurella dagmatis	260913656	SPDI -	TYY
	Pasteurella multocida	15602663	SPI -	· - · T - · · ·   - · T - · · · · · · · · · · · · · · · ·
	Citrobacter koseri	157145618	SOD	EDTGTV - Honoroo
	Dickove Zee	051700245		
	Dickeya Zeae	201709345		
	Erwinia pyritoliae	259908340	K	EDSGIVH
	Escherichia coli	117623540	K	EDTGTVH
	Klebsiella variicola	288935896	K	EDTGTVH
	Pantoea ananatis	291617602	K	EDSGTVH
	Providencia stuartii	183599250	K	FDS-AH
	Salmonalla enterica	161503186	K	EDTOTV - H
		101303100	o op	
	Shigella boydii	82544265	K	EDIGIVH
<b>A</b> 11 <b>A</b>	Xenorhabdus bovienii	290475309	K	EDS-AH
Other Gamma	Yersinia aldovae	238757085	EK	EDS-TVH
Proteobacteria	Aeromonas hydrophila	117621224	-YSDESDIQL-E	VDSETI-TH-SQ
(0/500)	Tolumonas auensis	237808311	SE-PDT-I	VDTDTTDTH-AQ
(0/300)	Vibrio angustum	00570445		VDSETIDTH
	Tdiemening boltion	05710005		
	Idiomarina bailica	85/13205	-LSDEPDVEL-D	VDSDTL-THWTR
	Moritella sp. PE36	149912346	SD-PD1-L-D	VDSETIDTH-AQ
	Shewanella halifaxensis	167623974	S-ESDISD	VDDDTIDTH-SSK
	Xanthomonas albilineans	285018377	-YNE-PDIEHIAE	LDKET TQVA H R
	Xylella fastidiosa	15839026	-YSE-PDIEQHIAE	LDKETTQVAHR
	Cardiobacterium hominis	258544287	NDDRV-IH-AD	LDQQML-NQSK
	legionella drancourtii	254498044	-YNE-SDI-IKL-E	VDSDTV-TH-ASB
	Methylophaga thiogyidans	254490577		VNSETV-TH-A-AB
	We chy tophaga chi tooxidans	204430377		
			61	
( <b>B</b> )	Haemophilus influenzae	148828339	61 VTFTNKAAAEMRHRIQSTLA	104 HQLVGMWIGTFHSIAHRLLR
( <b>B</b> )	Haemophilus influenzae Haemophilus ducrevi	148828339 33152168	61 VTFTNKAAAEMRHRIQSTLA KI	104 HAQ HQLVGMWIGTFHSIAHRLLR SS-1-R-FV
( <b>B</b> )	Haemophilus influenzae Haemophilus ducreyi Haemonhilus narasuis	148828339 33152168 219871258	61 VTFTNKAAAEMRHRIQSTLA K 	104 TAQ HQLVGMWIGTFHSIAHRLLR SSR-FV SSD -R-FVN
(B)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus parasu	148828339 33152168 219871258 170718056	61 VTFTNKAAAEMRHRIQSTLA KH NEYS 03 EYS 03	104 HAQ HQLVGMWIGTFHSIAHRLLR SSR-FV
( <b>B</b> )	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus	148828339 33152168 219871258 170718056	61 VTFTNKAAAEMRHRIQSTLA KH 	104 HQLVGMWIGTFHSIAHRLLR SSR-FV SSD -R-FVN (SH QR-FN SD - R-F
( <b>B</b> )	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida	148828339 33152168 219871258 170718056 15602276	61 VTFTNKAAAEMRHRIQSTLA K 	104 IAQ HQLVGMWIGTFHSIAHRLLR SS - R-FV
(B)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis	148828339 33152168 219871258 170718056 15602276 260914154	61 VTFTNKAAAEMRHRIQSTLA KH 	104 HQLVGMWIGTFHSIAHRLLR SSR-FV
(B) Pasteurellales {	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens	148828339 33152168 219871258 170718056 15602276 260914154 52425423	61 VTFTNKAAAEMRHRIQSTLA KH 	104 HQLVGMWIGTFHSIAHRLLR SSR-FV
(B) Pasteurellales {	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319	61 VTFTNKAAAEMRHRIQSTLA K 	104 HQLVGMWIGTFHSIAHRLLR SS- R-FV
(B) Pasteurellales ( (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580	61 VTFTNKAAAEMRHRIQSTLA KH 	104 AQ HQLVGMWIGTFHSIAHRLLR SSD -R-FV
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinocenes	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934	61 VTFTNKAAAEMRHRIQSTLA KH 	104 HQLVGMWIGTFHSIAHRLLR SSR-FV
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act minor	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109	61 VTFTNKAAAEMRHRIQSTLA K 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SD-R-FV           SG-R-FV           SS-R-FV           SS QR-FV           SS RA-FV           SG NR-FV           SG NR-FV           SS RA-FV           SG NR-FV           SS RA-FV           SS RA-FV           SG NR-FV           SS RA-FV           SS RA-FV           SS RA-FV           SS RA-FV
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868283	61 VTFTNKAAAEMRHRIQSTLA KI 	104           IAQ         HQLVGMWIGTFHSIAHRLLR           SSD         -R-FV           SSD         -R-FV           SS         -R-FV           SS         QR-FV           SS         QR-FV           SS         QR-FV           SS         R-FV           SS         QR-FV           SS         QR-FV           SS         QR-FV           SS         QR-FV           SS         QR-FV           SS         -R-FV           SS         -R-FV           SS         -R-FV           SS         -R-FV           SS         -R-FV           SS
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. minor Agg. actinomycetemcomitans	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383	61 VTFTNKAAAAEMRHRIQSTLA KH 	104           HQLVGMWIGTFHSIAHRLLR           SSR-FV
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813	61 VTFTNKAAAEMRHRIQSTLA K 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SD-R-FV           SGD-R-FV           SS           SR-FV           SS           R-FV           SS           R-FV           SS           R-FV           SR           SR-FV           SS           R-FV           SG           NR-FV           SS           SR-FV           SG           SR-FV           SG           SR-FV           SG           NR-FV           SS           SS           SS           SS           SS           NR-FV           SS
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125	61 VTFTNKAAAEMRHRIQSTLA Ki 	104           IAQ         HQLVGMWIGTFHSIAHRLLR           SSD         -R-FV           SSD         R-FV           SSD         R-FV           SSD         R-FV           SGD         NR-FV           SSH         -R-FV           SSH
(B) Pasteurellales (20/20) →	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159	61 VTFTNKAAAAEMRHRIQSTLA KH 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SSD           R-FV           SGD           R-FV           SS           QR-FV           OR           JOB           QR-FV           SS           QR-FV           JAN           OR           SS           OR-FV           SS           OR           SS           OR-FV           SS           OR-FV           OR           OR-FV           SS           OR-FV           SS           OR-FV           OR           OR           OR           OR      <
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578	61 VTFTNKAAAEMRHRIQSTLA Ki 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SD-R-FV           SB-R-FV           SS           SR-FV           SS           QR-FV           SS           QR-FV           SS           R-FV           SG           NR-FV           SG           NR-FV           SG           NR-FV           SG           NR-FV           SG           NR-FV           SG           NR-FV           SS           NR-FV           SS           NR-FV           SS           NMF-V           SON           QR-FV           SLG           FGRG           SVRN
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693	61 VTFTNKAAAEMRHRIQSTLA 	104           IAQ         HQLVGMWIGTFHSIAHRLLR           SS-         -R-FV           SSD         -R-FV           SSD         -R-FV           SGR         -FV           SS         QR-FV           SS         QR-FV           SS         RR-FV           SS         QR-FV           SS         QR-FV           SS         QR-FV           OR         -F
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Aratohacter vinelandii	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942921	61 VTFTNKAAAEMRHRIQSTLA KI 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SSD           R-FV           SS           QR-FV
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pacudomara aguainosa	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 11605593	61 VTFTNKAAAEMRHRIQSTLA 	104           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV.           SD-R.FV.           SG-R.FV.           SS-R.FV.           SS           SR-FV.           SS           AR-FV.           SS           R-FV.           SS           R-FV.           SS           NR-FV.           SGD           NR-FV.           SGD           NR-FV.           SS           NR-FV.           SS           SS           SS           NMF-V.           JQN           QR-FV.           JQN           QR-F           JGN           QR-F           JGN           JGN </th
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593	61 VTFTNKAAAEMRHRIQSTLA 	104           IAQ           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SD           R-FV           SG           R-FV           SG           R-FV           SS           QR           R-FV           SS           QR           SS           GR
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441	61 VTFTNKAAAEMRHRIQSTLA KI 	104         IAQ       HQLVGMWIGTFHSIAHRLLR         SS-       R-FV         SSD       R-FV         SSD       R-FV         SS       QR-FV         SG       QR-FV         SS       QR-FV         DGN       QR-FV         DGW       GL         TNMGR
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967	61 VTFTNKAAAEMRHRIQSTLA 	104         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV.         SD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SS         AR-FV.         SS         R-FV.         SS         R-FV.         SS         NR-FV.         SGD         NR-FV.         SS         NR-FV.         SS         SS         OR         JON         QR-FV.         JON         QR-F.         JON         QR-F.         JON         JON
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella multocida Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484	61 VTFTNKAAAEMRHRIQSTLA 	104           IAQ           HQLVGMWIGTFHSIAHRLLR           SS-           R-FV           SD           R-FV           SG           R-FV           SS           QR-FV           SS           QR-FV           SS           QR-FV           SS           RR-FV           SS           RR-FV           SS           R-FV           SS           R-FV           SS           R-FV           SS           R-FV           SS           R-FV           OB           SS           R-FV           SS           R-FV           SS           R-FV           SS           QR-FV           SS           QR-FV           SS           QR-FV           SS           QR-FV           SS           QR-FV           SS           QR-FV           SS
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376	61 VTFTNKAAAEMRHRIQSTLA KI 	104         IAQ       HQLVGMWIGTFHSIAHRLLR         SSD       -R-FV         SSD       -R-FV         SSD       -R-FV         SSD       -R-FV         SS       QR-FV         SS       QR-FV         SS       QR-FV         SS       QR-FV         SSH       -R-FV         SGN       NR-FV         OSN       QR-FV         OSN       QR-FV         OSN       QR-FV         SS       SS         NMFV       N
(B) Pasteurellales (20/20)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376	61 VTFTNKAAAEMRHRIQSTLA KH 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV.         SD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSR-FV.         SSR-FV.         SGD-NR-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSH-R-FV.         SS-NMF-V.         OGN-R-FV.         DGN QR-FV.         DGN QR-F.         DGN QR-F.         DGN QR-F.         TSGG
(B) Pasteurellales (20/20) →	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 15714441 307132967 269137484 188532376 43297 206579213	61 VTFTNKAAAEMRHRIQSTLA 	104         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV         SD-R-F-V         SSD-R-F-V         SSD-R-F-V         SSGR-FV         SSGR-FV         SSGR-FV         SSGR-FV         SSGR-FV         SSGR-FV         SSGR-FV         SSHR-FV         SSHR-FV         SSHR-FV         SSHR-FV         SSHR-FV         SSHR-FV         SSKR-GL         SSKR-FV         SSKR-FV         SSKR-FV         SSKR-FV         SSKR-R-FV         DQN QR-FV         DGN QR-FV         SSKR         DGVR-GL         TNMGR         GL         TSQG
(B) Pasteurellales (20/20) →	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Astoater vinelandii Pseudomonas aeruginosa Citrobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhadus luminescens	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453	61 VTFTNKAAAEMRHRIQSTLA 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV         SSD         R-FV         SG         R-FV         SS         R-FV         SS         QR-FV         SS         R-FV         SS         R-FV         SS         QR-FV
(B) Pasteurellales (20/20) •• Other Gamma Proteobacteria	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 277528453	61 VTFTNKAAAEMRHRIQSTLA KI 	104         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV.         SD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSB-R-FV.         SSB-R-FV.         SGD-NR-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SSD-R-FV.         SS-NMF-V.         OGN QR-FV.         DGN QR-F.         TSPM
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 15714441 307132967 269137484 188532376 43297 206579213 37528453 227357154	61 VTFTNKAAAEMRHRIQSTLA 	104         HQL VGMWIGTFHSIAHRLLR         SS-         R-FV         SD         R-FV         SG         R-FV         SS         QR-FV         SS         QR-FV         SS         QR-FV         SS         QR-FV         DGN         QR-FV         DGN         QR-FV         DGV         GL
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Previdencia stuartii	148828339 33152168 219671258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352	61 VTFTNKAAAEMRHRIQSTLA 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV         SSD         R-FV         SSD         R-FV         SS         R-FV         SS         QR-FV         SS         R-FV         SS         R-FV         SS         R-FV         SS         QR-FV         SS         RTHGR         GL         TSQG
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352 161505541	61 VTFTNKAAAEMRHRIQSTLA KI 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-F-         SD         R-F-         SS         SR-F-         SS         SR-F-         SS         SS         SS         AR-F-         SS         SS         NM-F-         SS         SS         NM-F-         V         SS         DGN         R-F-         SS         NM-         QR-F-         SS         DGN         R-F-         SS         NM-         QR         FF-         DGN         R-F-
<ul> <li>(B)</li> <li>Pasteurellales (20/20)</li> <li>→</li> <li>Other Gamma Proteobacteria (1/500)</li> </ul>	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 15714441 307132967 269137484 188552376 43297 206579213 37528453 227357154 188026352 161505541 30064891	61 VTFTNKAAAEMRHRIQSTLA 	104         HQL VGMUIGTFHSIAHRLLR         SS-         R-FV         SD-R-F-V         SSD-R-F-V         SSD-R-F-V         SS         QR-FV         SS         QR-FV         SS         QR-FV         SS         QR-FV         SS         RR-FV         SS         QR-FV         DGN         QR-FV         DGVR         GL
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304	61 VTFTNKAAAEMRHRIQSTLA 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV         SSD         R-FV         SSD         R-FV         SS         QR-FV         SS         R-FV         SS         QR-FV         SS         R-FV         SS         R-FV         SS         R-FV         SS         QR-FV         SS         R-FV         SS         R-FV
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis Xanthomonas axononodis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304 21244868	61 VTFTNKAAAEMRHRIQSTLA KI 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV.         SD-R-FV.         SS-         SR-FV.         SS         R-FV.         SS         RAFFV.         SS         SR         SS         RAFFV.         SS         SR         SS         RAFFV.         SS         SS         NR-FV.         SS         SS         NR-FV.         SS         SS         NR-FV.         SS         NR-FV.         SS         NMF-V.         SS         NMF-V.         SS         NMR-FV.         SS         DGN         QR-FV.         SS         NMF.V.         SVR         TSPM.         GL         TSPM.         SSVRN.         GL         TSQG         GL         TSQG <t< th=""></t<>
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis Xanthomonas axonopodis	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 15714441 307132967 269137484 188552376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304 21244868 292487322	61 VTFTNKAAAEMRHRIQSTLA 	104         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV-         SD-R-F-V         SS-         R-FV-         SS         NMF-V-         SS         NMF-V-         SS         NR-FV-         SS         NMF-V-         SS         NR-FV-         SS         NMF-V-         DGN         SSVRN
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. actinomycetemcomitans Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis Xanthomonas axonopodis Nitrosococcus halophilus	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254382319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304 21244868 292493733	61 VTFTNKAAAEMRHRIQSTLA 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV         SSD         R-FV         SSD         R-FV         SS         GR-FV         SS
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis Xanthomonas axonopodis Nitrosococcus halophilus Alcanivorax borkumensis	148828339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188532376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304 2124468 292493733 110835551	61 VTFTNKAAAEMRHRIQSTLA 	104         IAQ         HQLVGMWIGTFHSIAHRLLR         SS-         R-FV.         SD         R-FV.         SS         R-FV.         SS         R-FV.         SS         R-FV.         SS         R-FV.         SS         R-FV.         SS         R-FV.         SGD         NR-FV.         SS         SR         SS         SGR         NR-FV.         SS         SS         NR-FV.         SS         SS         NMF-V.         SS         SS         SS         NMF-V.         DGN         QR-FV.         DGN         QR-FV.         DGN         QR-FV.         DGN         QR-FV.         DGN         QR-F.         DGN         QR-F.         DGN         QR-F.         DGN
(B) Pasteurellales (20/20) → Other Gamma Proteobacteria (1/500)	Haemophilus influenzae Haemophilus ducreyi Haemophilus parasuis Haemophilus somnus Pasteurella multocida Pasteurella dagmatis Man. succiniciproducens Man. haemolytica Act. pleuropneumoniae Act. succinogenes Act. minor Agg. actinomycetemcomitans Agg. aphrophilus Tolumonas auensis Aeromonas hydrophila Idiomarina baltica Shewanella baltica Azotobacter vinelandii Pseudomonas aeruginosa Citrobacter koseri Dickeya dadantii Edwardsiella tarda Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Photorhabdus luminescens Proteus mirabilis Providencia stuartii Salmonella enterica Shigella flexneri Yersinia pestis Xanthomonas axonopodis Nitrosococus halophilus Alcanivorax borkumensis Oceanospirillum sp. MED92	148928339 33152168 219871258 170718056 15602276 260914154 52425423 254362319 307250580 152978934 240950109 261868383 251792813 237807125 117619159 85711578 126172693 226942221 116053593 157144441 307132967 269137484 188522376 43297 206579213 37528453 227357154 188026352 161505541 30064891 22124304 2124808 292493733 110835551 89092193	61 VTFTNKAAAEMRHRIQSTLA 	104         HQL VGMUIGTFHSIAHRLLR         SS-         R-F-         SD-R-F-         SS-RF-         SS         R-F-         SS         R-F-         SS         RF-         SSS         RF-

					223			264	
(A)	1	(Pasteurella multocida	1	15602549	NRTFERAQHLVT	KLDGA ENVC	VLA	LTQLQEGLNQADIVISST	
		Pasteurella dagmatis	6	60914298	E	QS -HI-	I-S	-DDQDK	
		Agg. actinomycetemcomi	tans 6	61867850	LAEAE	S- A-I-	s	-EQT	
Destaur		Agg. aphrophilus	Ę	51792200	LAET-LD	ERP Q	AIG	i-ER	
Pasteuro	enates	Haemophilus somnus	-	70717508	LSEKE	ETT QKID	IFS	-DR-SKRT	
(Clade	e 1)	Haemophilus influenzae		301156551	LSEQE	T-ASN TLIE	-YS	-DETA	
13/2	20	Man. succiniciproducen	s 2	2425379	LAELE	EHN KYI-	s	-QD	
		Act. succinogenes		152978788	BAFAA	- FSP FTF	IT-S		
		Act minor	ŗ	57465497	HTEM-AE	NVP	Ι τ.s	SATV	
<b>.</b> .		Act nleuroppeumoniae	ŕ	65975865	POFT-AF	B-NTP M-	T-5	SAT	
Pasteur	ellales (	Haemonhilus parasuis		67854674	HTEM-AV	A TP M	1 T.S	S-SATVC	
(Clad	e 2)	Man beenolytica		54362977	HTEM-AE		T . S	S-SA V	
6/7		Citrobacter koseri	ì	57145531			.19	SSDTD_B_BE	
		Chanabaatan sakazakii		56022674			-10		
		Edwardsielle tende		04625700			- 10		
		Edwardsleila tarda		94035762			-11		
		Erwinia pyriroitae		1000			-10		
		Escherichia coli		1000	R1-AD		-1-	SDID-RMREI	
Other Co	mma	Riebsiella pheumoniae		00080891	KA-AD		-1-	-SDID-R-REI	
Duter Ga		Proteus mirabilis		9/28495/	KK-AN		-11	-5010-5-5	
Proteoba	icteria	Providencia rustigiani	1 (	61343910	IEL-AK	EVNAQ	-18	S-ADIDSR-SE	
(0/50	0)	Serratia odoritera		/026142/	RL-AD	EVGAE	-11	-PEID-R-ADI	
		Snigella dysenteriae		2776550	HI-AD	EVGAE	-1-	-SDVD-R-REI	
		Xenornabdus bovienii		90475214	KI-A5		-18		
		Photobacterium profund	um 4	4309995	KAN-AE	EFGAE	- 10		
		Vibrio dunnicaii		03001039	RLO-AG		-1-		
		VIDELO TUENISSII		00/0//34	KWIN-AC	GENAE	-1-	-NEIFDI-An	
				222					274
( <b>B</b> )	Act. s	succinogenes	1529787	222 782 KGAML	SHGNLITSVMQCA	WIAIPFIGNH	SR	QRKAILPLPLYHIFAVSVN	274 CLLF
(B)	Act. s Man. s	succinogenes succiniciproducens	1529787 2425413	222 782 KGAML 3	SHGNLITSVMQCA	WIAIPFIGNH	SR R-	QRKAILPLPLYHIFAVSVN E-IIVL	274 CLLF A
( <b>B</b> )	Act. s Man. s Haemop	succinogenes succiniciproducens hilus somnus	1529787 2425413 7071742	222 782 KGAML 3 26	SHGNLITSVMQCA IN-F-AK TINIF-A	WIAIPFIGNH ESDR SV-D-	SR R- KK	QRKAILPLPLYHIFAVSVN E-IIVL IALTA	274 CLLF A
(B) Pasteurellales {	Act. s Man. s Haemop Haemop	succinogenes succiniciproducens shilus somnus shilus influenzae	1529787 2425413 7071742 7059398	222 782 KGAML 3 26 39	SHGNLITSVMQCA IN-F-AK TINIF-A- TIN-F-AK	WIAIPFIGNH ESDR SV-D- ED-	SR R- KK 	QRKAILPLPLYHIFAVSVN E-IILTA- T-SAVLTA-	274 CLLF A
(B) Pasteurellales (Clade 1)	Act. s Man. s Haemop Haemop Pasteu	succinogenes succiniciproducens shilus somnus shilus influenzae urella dagmatis	1529787 2425413 7071742 7059398 6091396	222 782 KGAML 3 26 39 58	SHGNLITSVMQCA IN-F-AK TINIF-A- TIN-F-AK I-VN-F-AN	WIAIPFIGNH ESDR SV-D- ED- EV-DR	SR R- KK 	QRKAILPLPLYHIFAVSVN E-IILTA- T-SAVLTA- EIAVLT EIAVLT	274 CLLF A
(B) Pasteurellales (Clade 1) 13/20	Act. s Man. s Haemop Haemop Pasteu Pasteu	succinogenes succiniciproducens ohilus somnus shilus influenzae urella dagmatis urella multocida	1529787 2425413 7071742 7059398 6091396 5602572	222 782 KGAML 3 26 39 58 20	SHGNLITSVMQCA IN-F-AK TINIF-A- TIN-F-AK I-VN-F-AN I-VNLF-AN	WIAIPFIGNH ESDR ED- EV-DR EV-DR	SR R- KK  TK	QRKAILPLPLYHIFAVSVN E-IIA	274 CLLF A
(B) Pasteurellales (Clade 1) 13/20	Act. s Man. s Haemop Haemop Pasteu Pasteu Agg. a	succinogenes succiniciproducens bhilus somnus bhilus influenzae urella dagmatis urella multocida actinomycetemcomitans	1529787 2425413 7071742 7059398 6091396 5602572 6186833	222 782 KGAML 3 26 39 58 2 38	SHGNLITSVMQCA IN-F-AK TIN-F-AK IN-F-AK I-VN-F-AN I-VNLF-AN	WIAIPFIGNH ESDR ED- EV-DR EV-DR EV-DR Y-V-R	SR R- KK  TK G-	QRKAILPLPLYHIFAVSVN E-IIALTA- T-SAVLTA- EIAVLT EIAVLT E-LAVLT	274 CLLF A
(B) Pasteurellales (Clade 1) 13/20	Act. s Man. s Haemop Haemop Pasteu Agg. a Agg. a	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus	1529787 2425413 7071742 7059398 6091396 5602572 6186833 5179278	222 782 KGAML 3 26 39 38 38 38 37	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK I-VN-F-AK	WIAIPFIGNH ESDR ED- EV-DR EV-DR YVR YV-GR	SR R- KK	QRKAILPLPLYHIFAVSVN E-IIA	274 CLLF A
(B) Pasteurellales (Clade 1) 13/20	Act. s Man. s Haemop Haemop Pasteu Agg. a Agg. a Agg. a	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor	1529787 2425413 7071742 7059398 6091396 5602572 6186833 5179278 2304192	222           782         KGAML           3            39            38            38            38            37            37	SHGNLITSVMQCA INF-AK TINIF-A- TI-VN-F-AK I-VNLF-AN I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YVR YV-GR YLLR-S	SR R- KK  TK G- H- K	QRKAILPLPLYHIFAVSVN E-IIAVLTA- T-SAVLTA- EIAVLT E-LAVLT E-LAVLT SKIGVIVLT SKIGVIVL	274 CLLF  
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales -	Act. s Man. s Haemop Haemop Pasteu Agg. a Agg. a Act. r Act. r	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae	1529787 2425413 7071742 7059398 6091396 5602572 6186833 5179278 2304192 1659758	222           782         KGAML           3            39            38            38            37            37            36            37            36            37            36	SHGNLITSVMQCAN INIF-A- TINIF-AK I-VN-F-AN I-VNLF-AN I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK VANLK	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YV-R YV-R E-LLR-S -V-E-L-R-S	SR R- KK FK H K - 0	QRKAILPLPLYHIFAVSVN E-II	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales - (Clade 2)	Act. s Man. s Haemop Pasteu Pasteu Agg. a Agg. a Act. r Act. p Haemop	succinogenes succiniciproducens shilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor pleuropneumoniae shilus parasuis	1529787 2425413 7071742 7059396 5602572 6186833 5179276 2304192 1659756 1987046	222           KGAML           3              39              38              37           -22              358	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK VANLK K K K K K K 	WIAIPFIGNH ESDP ED- EV-DR YV-GR Y-V-GR E-LLR-S -V-E-L-R-S -V-E-L-R-S -V-E-L-R-S -V-E-L-R-S	SR R- KK	QRKAILPLPLYHIFAVSVN E-IIAVLTA- T-SAVLT EIAVLT E-LAVLT E-LAVLT SKIGVIVLT SKIGVIV-L E-IAVV-LT E-IAVV-LT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pasteu Agg. a Agg. a Act. r Act. p Haemop Man. l	succinogenes succiniciproducens ohilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor bleuropneumoniae ohilus parasuis naemolytica	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179278 2304192 1659758 1987046 5436296 5436296	222           782         KGAML           3            36            37            37            358            362            37            358            37            358            370            371	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANLK VANL-AK T-QANM-AK T-QANM-AK	WIAIPFIGNH ESDR EV-DR EV-DR YV-DR YV-GR YV-GR E-LLR-S -V-E-LLR-S -V-Y-L-QRS VE-LL-S	SR R- KK  TK  K  K  A	QRKAILPLPLYHIFAVSVN E-I-I-I	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pastel Agg. a Agg. a (Act. r Haemop Man. I (Aeromo	succinogenes succiniciproducens ohilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas hydrophila	1529787 2425413 7071742 7059396 6091396 5602572 6186833 51792762 2304192 1659756 1987048 5436296 1761877	222           782         KGAML           3            26            39            38            37            36            37            38            36            37            38            36            37            38            39            36            37	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANILAK S-V-ANIL-AK T-QANMAK T-RAN-EL	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YV-CR E-LLR-S -V-E-L-R-S -V-Y-L-QRS VE-LL-S GVYG-MLERG	SR R- KK  TK G- H- K- Q A	QRKAILPLPLYHIFAVSVN E-I-IV-L T-SAV-LT EIAV-LT E-LAV-LT E-LAV-LT SKIGVIV-LT ECIAVV-L EIGVIAV-LT MIGLVVL-L-M- KEEVVTAV-LT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pastel Pastel Agg. a Agg. a Agg. a Act. r Haemop Man. H (Aeromo Aeromo	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas salmonicida	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179276 2304192 1659756 1987046 5436296 1761877 4529906	222           782         KGAML           3            26            38            38            37            36            37            36            37            36            37            38            37            38            35            36            37	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANIF-AK T-QANM-AK T-QANM-AK T-RAN-EL T-R-M-AN-E-L	WIAIPFIGNH ESDR EV-DR EV-DR YVR YVR E-LLR-S -V-E-L-R-S -V-Y-L-QRS VE-LL-S GVYG-MLERG GVYG-MLERG	SR R- KK  TK  K- QA	QRKAILPLPLYHIFAVSVN E-I-IV-L T-SAV-LT EIAV-LT E-LAV-LT E-LAV-LT SKIGVIV-LT ECIAVV-L E-IGVIAV-LT MIGLVVL-L-M- KEFVVTAV-LT E-VVTAV-LT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pasteu Pasteu Agg. a Agg. a Agg. a Act. r Haemon Man. l Act. o Haemon Acromo	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas salmonicida ya dadantii	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179276 2304192 1659756 1987046 5436296 1761877 4529906 7150052	222           782         KGAML           3            26            38            38            38            36            37            358            358            358            358            368            37            38            37	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK VANIF-AK VANIL-AK T-QANM-AK T-RAN-EL T-R-MQANLE-AK	WIAIPFIGNH ESDR EV-DR EV-DR YVR E-LLR-S V-E-LLR-S V-Y-L-CRS VE-LL-S GVYG-MLERG GVYG-MLERG GVYG-VLH0G AYYG-VLH0G	ЯВ В К	QRKAILPLPLYHIFAVSVN E-I-I-I	274 CLLF A
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemoop Pasteu Pasteu Agg. a Agg. a Agg. a Act. r Act. p Haemoo Man. l Acromo Aeromo Dickey Eschei	succinogenes succiniciproducens shilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae shilus parasuis haemolytica onas hydrophila onas salmonicida ya dadantii richia coli	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179275 2304192 1659756 1987046 5436297 4529906 7150052 9344617	222           782         KGAML           3            36            37            38            358            356            357            368            37            368            358            36            37            36            37	SHGNLITSVMQCA INF-AK TINIF-A- TI-VN-F-AK I-VN-F-AK I-VN-F-AK I-VN-F-AK VANLK VANLK T-RAN-EL T-R-MCAN-EL T-R-MLANLE-VN T-R-MLANLE-VN	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YVR YVR YVR E-LLR-S -V-E-LRS -V-E-LLS GVYG-MLERG GVYG-MLERG GVYG-LLHOG AAYG-VLHGG AAYG-VLHGG	SR - KK	QRKAILPLPLYHIFAVSVN E-IIVLT T-SAVLT EIAVLT E-LAVLT E-LAVLT SKIGVIVLT SKIGVIAVLT MIGLVVLT KEFVVTAVLT KEFVVTALT KELVVTALTI- KEAVVTALTI-	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pasteu Pasteu Pasteu Agg. a Agg. a Agg. a Agg. a Agg. a Act. p Haemop Man. I Acromo Dickey Eschei Provid	succinogenes succiniciproducens succiniciproducens shilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas salmonicida ya dadantii richia coli dencia rustigianii	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179275 1987046 5436296 1761877 4529900 7150052 9344611 6134383 706292	222           782         KGAML           3            36            37            38            37            358            358            358            358            358            36            37            36	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK I-VN-F-AK VANLK VANLK S-V-ANIL-AK T-RAN-EL T-R-M-AN-EL T-R-MLANLE-VN 	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YVR YV-GR YV-GR Y-L-GRS VE-LL-S GVYG-MLERG GVYG-MLERG AAYG-VLHGG AAYG-VLHGG AAYG-VLHGG AAYG-VLHGG	SR - K K Q A	QRKAILPLPLYHIFAVSVN E-I-I	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7	Act. s Man. s Haemop Pastel Pastel Agg. a Agg. a Agg. a Agg. a Act. r Act. r Haemop Man. l Act. s Dickey Escher Provid Serrat	succinogenes succiniciproducens ohilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor bleuropneumoniae ohilus parasuis naemolytica onas shydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera	1529787 2425413 7071742 7059396 6091396 5602572 618683 5179275 1987048 5436296 1761877 4529906 9344617 6134383 7026220	222           782         KGAML           3            36            37            38            37            38            37            38            37            36            35            36            36            36            36            36	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AN I-VN-F-AK VANIF-AK VANIK VANIAK T-RAN-EL T-R-MQANLAK T-R-MLANIE-VN T-R-MLANIA-AR T-R-MQANLA-N T-S-MANIA-N	WIAIPFIGNH ESDR SV-D- EV-DR EV-DR YVR YV-GR E-LLR-S -V-Y-L-QRS VE-LL-S GVYG-MLERG AAYG-VLHQG AAYG-VLHQG AAYG-LFHDG AAYG-LFRDG AAYG-LFRDG	SR - K K Q A	QRKAILPLPLYHIFAVSVN E-I-I	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma	Act. s Man. s Haemop Pasteu Pasteu Pasteu Agg. a Agg. a Act. r Haemop Man. H (Aeroma Act. or Dickey Eschell Provid Serrai Vibrid	succinogenes succiniciproducens ohilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae ohilus parasuis naemolytica onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179272 2304192 1659756 1987046 5436296 1761877 45299062 9344617 6134383 7026222 6077634	222           782         KGAML           3            26            39            38            37            36            37            36            37            36            36            36            36            36            36            36            36            36	SHGNLITSVMQCA INIF-A- TINIF-A- I-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANILK VANIL-AK T-RAN-EL T-R-MQANL-AR T-R-MLANIE-VN T-R-MLANIA-AR T-R-MQANLA-N T-R-MQANLA-N T-R-MQANLA-N	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YV-CR E-LLR-S -V-E-L-R-S -V-Y-L-QRS VE-LL-S GVYG-MLERG GAYG-VLHGG AAYG-VLHGG AAYG-VLHGG GAYG-VLAPG GMYG-VLAPG GMYG-VLAPG	SR-KK-QA	QRKAILPLPLYHIFAVSVN E-I-IV-L T-SAV-LT EIAV-LT E-LAV-LT E-LAV-LT SKIGVIV-LT ECIAVV-LT MIGLVVL-L-M- KEFVVTAV-LT KEFVVTALT KELVVTALT RELVVTALT RELVVTALT REVVTALT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma Proteobacteria	Act. s Man. s Haemop Pasteu Pasteu Agg. a Agg. a Act. r Haemop Man. H (Aeroma Aeroma Dickey Escheu Provia Serrat Vibria	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179278 2304192 1659756 1987048 5436296 1761877 4529906 7150052 7150052 7150052 607763 292206	222           782         KGAML           3            26            38            38            37            36            37            36            37            36            355            36            37            36            37            36            37	SHGNLITSVMQCA INIF-A- TINIF-A- I-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANLK T-R-M-AN-EL T-R-M-AN-EL T-R-MLANLE-VN T-R-MLANLE-VN T-R-MLANLE-AK T-R-MLANLE-AK T-R-MLANLE-AK T-R-MLANLE-AK T-R-MLANLE-AK T-R-MLANLE-AK T-R-MLANLE-AK	WIAIPFIGNH ESDR SV-DR EV-DR EV-DR YV-GR YV-GR E-LLR-S -V-Y-L-QRS VE-LL-S GVYG-MLERG GVYG-MLERG GVYG-VLHGG AAYG-VLHGG AAYG-VLHGG GAYG-VLAFG GMYG-VLAFG GAYG-VLAFG GAYG-VLAFG	SR-KK-QA	QRKAILPLPLYHIFAVSVN E-I-IV-L, T-SAV-LT EIAV-LT E-LAV-LT SKIGVIV-LT ECIAVV-LT MIGLVVL-L KEFVVTAV-LT KEFVVTALT ELIVTALT RELVVTALT RELVVTAV-LT RELVVTAV-LT RELVVTAV-LT RELVVTAV-LT RELVVTAV-LT RELVVTAV-LT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma Proteobacteria (0/500)	Act. s Man. s Haemop Pasteu Pasteu Agg. a Agg. a Act. r Haemon Act. p Haemon Act. p Haemon Serra Vibrid Vibrid Shows	succinogenes succiniciproducens ohilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae ohilus parasuis haemolytica onas hydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi o vulnificus mala benthica	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179278 2304192 1659756 1987046 5436296 1761877 4529906 715052 9344611 6134383 7026220 607763 2922083 7363615 637524	222           782         KGAML           3            26            38            38            37            36            37            36            37            36            355            36            37            36            36            36            36            36	SHGNLITSVMQCA IN-F-AK TIN-F-AK TI-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK T-A-IVANIF-AK T-A-IVANIF-AK T-QANMAK T-QANM-AN-EL T-R-MQANLAN T-R-MLANIA-AR T-R-MLANIA-AR T-R-MQANLAN T-S-M-ANIL-AK T-R-M-ANAK T-R-M-ANAK T-R-M-ANAK	WIAIPFIGNH ESDR EV-DR EV-DR EV-DR YVR E-LLR-S E-LLR-S V-E-L-R-S GVYG-MLERG GVYG-MLERG GAYG-VLHFG AAYG-VLHFG GAYG-VLHFG GMYG-VLEGG GMYG-VLAPG GMYG-VLAPG GMYG-VLAPG GMYG-VLAPG GMYG-VLAPG GMYG-VLAPG		QRKAILPLPLYHIFAVSVN E-I-I-I	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma Proteobacteria (0/500)	Act. s Man. s Haemop Pasteu Pasteu Agg. a Agg. a Agg. a Agg. a Act. r Act. p Haemop Man. l Acroma Dickey Escher Provid Serrai Vibrid Vibrid Shewai	succinogenes succiniciproducens shilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae ohilus parasuis naemolytica onas hydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi o vulnificus nella sediminis	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179275 13987046 5436296 7150052 9344617 6134383 7026222 6077634 2922083 7363619 6375243	222           782         KGAML           3            36            37            38            37            358            358            358            358            358            36            37            38            35            36            37	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK VANLK X-ANIL-AK T-R-MLANIE-VN T-R-MLANIA-AR T-R-MLANIA-AR T-R-MANIA-AR T-R-MANIA-AR T-R-MANIA-AR T-R-MANIA-AR T-R-MANIA-AK T-R-MANIA-AK T-R-MANIA-AK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-MANAK T-R-VVSNLL-AN	WIAIPFIGNH ESDR EV-DR EV-DR YV-GR YV-GR YV-GR Y-L-GRS Y-L-GRS GVYG-MLERG GAYG-VLHGG AAYG-VLHGG GAYG-VLHFG GAYG-VLHFG GAYG-VLHFG GAYG-VLAFG GMYG-VLEG GMYG-VLEG GMYG-VLAFG GMYG GMYG-VLAFG GMYG GMYG-VLAFG GMYG GMYG GMYG GMYG GMYG GMYG GMYG GM	RRKK-QA	QRKAILPLPLYHIFAVSVN E-IIALTA- T-SAV-LT EIAV-LT E-LAV-LT E-LAV-LT ECIAVV-LT ECIAVV-LT ECIAVV-L ECIAVV-L EIGVIAV-LT ELVVTALT KEFVVTALT REVVTALT REVVTALT REVVTALT REVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT RELVVTALT	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma Proteobacteria (0/500)	Act. s Man. s Haemop Pasteu Pasteu Pasteu Pasteu Agg. a Agg. a Agg. a Agg. a Agg. a Act. p Haemop Man. h Act. p Haemop Man. l Act. s Provia Secher Provia Secher Vibrid Shewan Shewan	succinogenes succiniciproducens succiniciproducens shilus somnus ohilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae ohilus parasuis naemolytica onas shydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi o vulnificus nella benthica nella sediminis arina loibiensis	1529787 2425413 7071742 7059396 6091396 5602572 618633 5179275 1987046 5436296 1761877 4529900 7150052 9344617 6134383 7026220 6077632 7363615 6375243 5737565 6460907	222         782       KGAML         3          36          37          38          37          38          37          38          37          38          35          36          37          38	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK I-VN-F-AK T-A-IVANIF-AK VANLK VANLK T-R-M-AN-EL T-R-M-AN-EL T-R-MANL-AK T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR T-R-MANLANIA-AR 	WIAIPFIGNH ESDR SV-DR EV-DR EV-DR YVR YV-GR YV-GR YV-GR YV-GR YV-GR YV-GR YV-GR YV-GR GVYG-MLERG GAYG-VLAFG GMYG GMYG-VLAFG GMYG GMYG-VLAFG GMYG-VLAFG GMYG GMYG GMYG GMYG GMYG GMYG GMYG GM	SR-KK-QA	QRKAILPLPLYHIFAVSVNN E-I-II	274 CLLF 
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 6/7 Other Gamma Proteobacteria (0/500)	Act. s Man. s Haemop Pasteu Pasteu Pasteu Agg. a Agg. a Agg. a Agg. a Act. p Haemop Man. h Act. s Haemop Man. h Act. s Haemop Serra Vibrid Serra Vibrid Shewal Shewal Idion	succinogenes succiniciproducens obilus somnus obilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus ninor oleuropneumoniae obilus parasuis naemolytica onas hydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi o vulnificus nella benthica nella sediminis arina loihiensis	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179275 1987048 5436296 1761877 4529906 176134383 7026220 6077634 2922083 7363613 6375243 5737566 6460923 5682263	222           782         KGAML           3            36            37            38            37            38            37            38            37            38            37            38            35            36            37            36	SHGNLITSVMQCA I-N-F-AK TI-N-F-AK I-VN-F-AN I-VN-F-AK I-VN-F-AK VANLK VANLK VANLAK T-R-MAAN-EL T-R-MAAN-E-L T-R-MAAN-E-L T-R-MAAN-E-L T-R-MAAN-E-L T-R-MAAN-E-L T-R-MAAN-AK T-R-MAAN-AK T-R-MAAN-AK T-R-MAAN-AK T-S-M-ANIL-AK T-R-M-ANAK XVSNLL-AN TVVSNLL-AD R-MVANL-VS	WIAIPFIGNH ESDR SV-DR EV-DR EV-DR YV-GR YV-GR YV-GR YV-GR YL-GR GVYG-MLERG AAYG-VLHGG AAYG-VLHGG GAYG-VLHGG GAYG-VLHGG GAYG-VLAPG GMYG-VLAPG GMYG-VLAPG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG SVIT-IMNDG AAYS-LLIDG SVIT-IMNDG		QRKAILPLPLYHIFAVSVNN E-I-I	274 CLLF 
<ul> <li>(B)</li> <li>Pasteurellales</li> <li>(Clade 1)</li> <li>13/20</li> <li>Pasteurellales</li> <li>(Clade 2)</li> <li>6/7</li> <li>Other Gamma</li> <li>Proteobacteria</li> <li>(0/500)</li> </ul>	Act. s Man. s Haemop Pasted Pasted Agg. a Agg. a Agg. a Agg. a Act. r Haemop Man. l Act. r Haemor Serrai Vibrid Vibrid Shewal Shewal Idioma Kangid	succinogenes succiniciproducens obilus somnus shilus influenzae urella dagmatis urella multocida actinomycetemcomitans aphrophilus minor oleuropneumoniae obilus parasuis naemolytica onas shydrophila onas salmonicida ya dadantii richia coli dencia rustigianii tia odorifera o coralliilyticus o harveyi o vulnificus nella benthica nella sediminis arina loihiensis ella koreensis nella pneumophila	1529787 2425413 7071742 7059396 6091396 5602572 6186833 5179276 1987046 5436296 1761877 4529906 9344617 6134383 7026226 6077634 2922083 5737566 6460927 568226	222           782         KGAML           3            26            38            38            37            38            37            38            36            36            36            36            36            36            36	SHGNLITSVMQCA IN-F-AK TIN-F-AK I-VN-F-AN I-VN-F-AN I-VN-F-AK T-A-IVANIF-AK VANLK VANLAK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-MCANL-AK T-R-VVSNLL-AN VVSNLL-AN VVSNLL-AN VVSNLL-AN VVSNLL-AN 	WIAIPFIGNH ESDR SV-DR EV-DR EV-DR EV-DR YV-CR ELLR-S -V-E-L-R-S -V-Y-L-QRS VE-LL-S GVYG-MLERG AAYG-VLHGG AAYG-VLHGG AAYG-VLHGG GMYG-VLHGG GMYG-VLHGG GAYG-VLHGG GAYG-VLHGG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG GAYG-VLAPG AAYS-LLIDG SVIT-IMNDG AWMG-LDEG		QRKAILPLPLYHIFAVSVNN E-I-IV-L T-SAV-LT EIAV-LT E-LAV-LT E-LAV-LT ECIAVV-LT ECIAVV-LT MIGLVV-L EIGVIAV-LT KEFVVTAV-LT KEFVVTALT KELVVTALT RELVVTALT RELVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT KEFVVTALT ETI-TASLC -DIIVTASLTA	274 CLLF 

Fig. 3 Partial sequence alignments of a glutamyl-tRNA reductase and b long-chain-fatty-acid-CoA ligase, each containing two CSIs of different lengths (*boxed*) at the same positions that are specific for the two Pasteurellales clades. The *dashes* in the sequence alignments indicate identity with the amino acid on the *top* line. In the case of Glutamyl-tRNA reductase, a 4 aa insert is present in various Clade I species,

for these proteins were not detected in one of the Pasteurellales species (viz. *H. ducreyi* or *Agg. actinomycetemcomitans*). Similarly, for four other proteins that contained Pasteurellales specific CSIs,

while all of the Clade 2 species contain a 2 aa insert in this position. In the long-chain-fatty-acid-CoA ligase, 2 aa and 1 aa inserts are found in the Clades 1 and 2 species, respectively. The different lengths of CSIs in these proteins serve to distinguish the Clades 1 and 2 species from each other. Sequence information for only a limited number of species from other bacterial group is presented here

their homologues were not detected in a few species from this group (Supplementary Figs. 27–30).

In a number of additional proteins, while the CSIs of interest are specifically present in most

Pasteurellales, they are lacking in 1-2 species. For example the 1 aa insert in 23S rRNA (guanosine-2'o)-methyltransferase and the 17 aa insert in glutamate ammonia ligase adenylyltransferase are specifically present in all Pasteurellales except H. parasuis (Supplementary Figs. 31-32). Likewise, the 1 aa inserts in murein transglycosylase C, ProS protein and D-methionine-binding lipoprotein are present in all Pasteurellales except Act. minor and the two Pasteurella species, respectively (Supplementary Figs. 33-35). The absence of CSIs in these Pasteurellales species could result from a variety of possibilities including deeper branching of these species in relation to other species or replacement of the gene containing CSI by a gene lacking the CSI by means of LGTs. However, at present these or other possibilities cannot be distinguished.

In addition to the above proteins that contained CSIs that were highly specific for either all or most Pasteurellales species, in a small number of cases the identified CSIs in addition to being shared by all or most Pasteurellales were also present in 1-2 isolated species from other Gammaproteobacteria. One example of such CSIs is a 3-4 aa insert in the DNA dependent helicase II (Fig. 2b), that is commonly shared by all sequenced Pasteurellales species as well as by Tolumonas auensis, belonging to the order Aeromonadales. However, this CSI is not present in other Aeromonadales. The other proteins containing Pasteurellales-specific CSIs with isolated exceptions include the presence of a 2 aa insert in the hypothetical protein NTO5HA\_0747 that is also shared by Psychrobacter sp. PRwf-1 (Supplementary Fig. 36A); a 2 aa deletion in the Lysyl tRNA synthetase that is also shared by Marinomonas sp. MWYL1 (Supplementary Fig. 36B); a 1 aa insert in the protein Cof, a haloacid dehalogenease-like hydrolase, that is also present in Pantoea sp. At-9b (Supplementary Fig. 37); a 4 aa deletion in 6-phophogluconolactonase that is also found in Cardiobacterium hominis (Supplementary Fig. 38), a 2 aa deletion in the geranyltranstransferase also present in Allochromatium vinosum, Marinobacter algicola and Marinobacter aquaeolei (Supplementary Fig. 39); and lastly a 3 aa insert in the DNA repair protein RecN that in addition to all Pasteurellales is also present in Cellvibrio japonicus and Psychromonas sp. CNPT3 (Supplementary Fig. 40). The shared presence of these CSIs in isolated species from other groups could result from a variety of possibilities including lateral gene transfer from Pasteurellales to these species; independent occurrence of similar genetic changes in these species; or that some of these species might be more closely related to the Pasteurellales and that they have been incorrectly assigned to these other genera/orders. We are unable to distinguish between these possibilities based upon the available data.

Molecular signatures distinguishing two main clades of Pasteurellales

The order Pasteurellales currently consists of a single family Pasteurellaceae and the interrelationship among different species/genera within this family is poorly understood (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). Thus, molecular markers that can provide reliable insights concerning the evolutionary relationships among these species should be of much interest. In phylogenetic trees, based upon two different large sets of protein sequences, the sequenced Pasteurellales species formed two distinct clades (Gioia et al. 2006; Redfield et al. 2006; Bonaventura et al. 2010), as confirmed in the present study (Fig. 1). Importantly, the existence of these two clades is independently strongly supported by the species distribution patterns of many CSIs that we have identified in the present work. A brief description of these CSIs is provided below.

The protein glutamyl-tRNA reductase, which catalyzes the NADPH-dependant reduction of glutamyl-tRNA to glutamyl-1-semialdehyde, contains two different lengths of CSIs in the same position that serve to distinguish various Pasteurellaceae species from all other bacteria and at the same time they also provide clear distinction between the Clades I and II species (Fig. 3a). In this case, a 4 aa insert in a conserved region is uniquely present in all of the Pasteurellales species that form Clade I (viz. Agg. actinomycetemcomitans, P. multocida, P. dagmatis, Act. succinogenes, Man. succinoproducens, H. somnus and H. influenzae), whereas in the various species that comprise Clade II, a 2 aa insert is present in the same position. Because these CSIs are related in sequence, the most likely explanation to account for them is that a 2 aa or 4 aa insert was initially introduced in a common ancestor of all Pasteurellales and it was followed by either a 2 aa insert in the Clade I species or a 2 aa deletion in the Clade II species. Similarly to glutamyl-tRNA reductase, in the protein long chain fatty acid-CoA ligase, which plays an important role in the breakdown of fatty acids, different lengths of CSIs in a conserved region are uniquely present in the two Pasteurellales clades (Fig. 3b). In this case, a 2 aa insert is present in all of the Clade I species, whereas the Clade II species have a 1 aa insert in this position. The presence of different lengths of CSIs in this protein can also be explained as above. Interestingly, the homologues of both of these proteins were not detected in *H. ducreyi*.

In addition to these CSIs that distinguish both Clades I and II species, we have also identified 11 CSIs in widely distributed proteins that are either uniquely or mainly found in the Clade I species (Table 3A). Two examples of such CSIs are presented in Fig. 4. In the universally distributed ribosomal protein S1, which plays a central role in protein synthesis, an eight amino acid deletion in a conserved region is uniquely present in all Clade I Pasteurellales species (Fig. 4a). The absence of this indel in all other Pasteurellales as well as other bacteria provides evidence that this indel represents a deletion in the Clade I species rather than an insert in other bacteria. Similarly, in the protein cytochrome-D-ubiquinol oxidase subunit 1, which is a component of the aerobic respiratory chain, a 5 aa insert in a conserved region is uniquely present in all Pasteurellales species belonging to Clade I, but not found in any other bacteria (Fig. 4b). Sequence alignments for other proteins which contain CSIs that are specific for Pasteurellales Clade I are presented in Supplementary Figs. 41-45. The CSIs in all of the above proteins are highly specific for Pasteurellales Clade I indicating that they were introduced in a common ancestor of this clade.

Four other proteins also contain CSIs that are largely specific for the Clade I. Within Clade I, *H. influenzae* shows deepest branching in the phylogenetic tree (Fig. 1). We have identified a 2 aa insert in the protein thiamine-monophosphate kinase that is commonly shared by all Clade I species except *H. influenzae* (Supplementary Fig. 46). The most likely explanation for this CSI is that the genetic change responsible for it occurred in a common ancestor of the remaining Clade I species after the branching of *H. influenzae*. For CSIs in three other proteins, the indels of interest are also present in an isolated species from Clade II in addition to the members of Clade I. For example, in the fumarate

**Fig. 4** Excerpts from the sequence alignments for **a** ribosomal  $\blacktriangleright$  protein S1 and **b** cytochrome D ubiquinol oxidase subunit 1, showing two different CSIs in conserved regions of these proteins that are uniquely present in various Clade 1 Pasteurellales species. The other CSIs those are specific for the Clade I species are listed in Table 3A. The *dashes* in the sequence alignments indicate identity with the amino acid on the *top* line

reductase iron-sulfur subunit, which is involved in the interconversion of fumarate and succinate, an 11 aa insert in a highly conserved region is uniquely present in various Clade I species and also H. parasusis, which shows deepest branching in the Clade II (Supplementary Fig. 47). Likewise, in the cell division protein FtsZ, a 3 aa insert is present in various Clade I species and also Man. haemolytica (Supplementary Fig. 48). The protein lysyl-tRNA synthetase also contains a 2 aa insert that is specific for the Clade I. However, in this case, only one of the H. somnus strain contains this CSI, whereas the other H. somnus strain has a more divergent homologue that lacks this indel (Supplementary Fig. 49). The species distribution patterns of these latter CSIs could result from a number of possibilities including LGT events or introduction of these genetic changes at various stages in the evolution of the Pasteurellales species that are not apparent from this tree.

The Pasteurellales species Act. pleuropneumoniae, Act. minor, H. ducreyi, Man. haemolytica and H. parasuis form Clade II in the phylogenetic tree (Fig. 1). As indicated above, the proteins glutamyltRNA reductase and long chain fatty acid-CoA ligase contain distinctive inserts that are specific for the Clade II species (Fig. 3). We have also identified a number of other CSIs that are specific for this clade (Table 3B). In the enzyme DNA adenine methylase, which is responsible for methylation of the newly synthesized strand of DNA, a 3 aa insert that is specific for the Clade II species is present in a highly conserved region (Fig. 5a). Other sequence alignments showing CSI specific to Pasteurellales Clade II (Table 3B) are shown in Supplementary Figs. 50–52. The genetic changes responsible for these CSIs were likely introduced in a common ancestor of the Clade II species and they strongly support the existence of this clade.

Within Clade II, the deepest branching in the phylogenetic tree is observed for *H. parasuis* (Fig. 1).

			462	503
(A)	(Agg. aphrophilus	251792146	DAKGAKVELDGGVEGYIRAADL	TNEVAAGDVVEAKYTGVDRK
(11)	Agg. actinomycetemcomitans	293390073		••••V•••••••••
	Act eveningeren	150030010	Δ.	
	Act. succinogenes	152979212	·····A····	FF
Pasteurellales	Haemophilus influenzae	46133579	S	V
i usteur enuies	Haemophilus somnus	113461119	TGIT	SVV
(Clade 1)	Man succinicinroducons	50405591	e N	DN
13/20	Man. Succinicipi oducens	52425551	-3N	-0N
15/20	Pasteurella dagmatis	260913659		S
	Pasteurella multocida	15602666		N
	Act plauroppoumoniag	100150052		
	Act. preuropheumonitae	190150052	VEAFNEA IND	RVEDI - 101511
	Act. minor	240949276	VTEANEA  TLD	RVEDI -SVISVAI
Pasteurellales 🗸	Man. haemolvtica	261492540	VEAFNEA TAE	RVEDI -SVISVSI
(Clade 2)	Haamonhilua nanacuia	010970701		
(Claue 2)	Haemophilius parasuis	2198/0/01	IRD	RVEDI - IVISVEI
7/7	Haemophilus ducreyi	33152424	-TVEAFNEA  TRE	RVEDI -TVISVSII
	Arsenonhonus nasoniae	284007586	TTAAHISEA SBD	
		157140400		
	Citrobacter Koseri	157146403	SEA SRD	RVEDAL -LVLSVEF
	Dickeya zeae	251789939	TADLSEA  SRD	RIEDA -LVLNVEI
	Escherichia coli	42837	TADISEA SBD	
:		42007		
	Kiedsiella pheumoniae	152969495	ADLSEA SRD	RVEDA -LVLSVEF
	Photorhabdus asymbiotica	253990303	TADLSEA  SRD	RVEDA -LVLNVA
	Proteus mirabilis	197284609		
		107204000		
	Providencia stuartii	188025797	LSEA  SRD	RVEDAL -QVLKVD
	Serratia odorifera	293396771	ESEA SRD	RVEDA -LVLNVDF
Other Gamma	Yersinia aldovae	238757619	TAI SEA TON	RVEDAL ALVINVA - E
Durate a based and a		230737013	LI SEA THU	
r roteopacteria	Sodalis glossinidius	85058971	-vLSEA  SRD	HVEDA -LVLSVDF
(0/500)	Vibrio cholerae	121591424	SEV SRD	RIEDA SLILNVKF
(	Grimontia bollisse	262274461	T. TE. I CEALODD	
	Bhatahaatandum	20221 4401	SRD	
	Photopacterium protundum	54309615	LSEA SVD	RVEDA -LVLSVSF
	Alteromonadales bacterium	119471943	VIAQE	RVEDA -TV-SVEVV
	Idiomarina baltica	85713208		BVEDA STILEV & DEM
		00/10200		NVEDA 31-L3V3RFM
	Pseudoalteromonas tunicata	88859273	I AQE	RVEDA -TA-SVEV
	Shewanella amazonensis	119774871	VTAEVI SRE	RVEDA STVFSVAFM
	Tolumonas augneis	227202214		
		207000014		
	Xylella fastidiosa	15839029	LIE-IVS-R-I ANE	RVDDA -QYLKVSFI-M
				0.00
			217	
			317	303
( <b>B</b> )	Agg. actinomycetemcomitans	293390515	317 RVRSGIQAYALLQQLRA EKKAN	GQASEETKAKFDKVQKDLGFGLLLK
<b>(B)</b>	Agg. actinomycetemcomitans Agg. aphrophilus	293390515 251793063	317 5 RVRSGIQAYALLQQLRA EKKAN	GQASEETKAKFDKVQKDLGFGLLLK
<b>(B)</b>	Agg. actinomycetemcomitans Agg. aphrophilus	293390515 251793063 152070454	317 5 RVRSGIQAYALLQQLRA EKKAN 3	GQASEETKAKFDKVQKDLGFGLLLK
<b>(B)</b>	(Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes	293390515 251793063 152979454	317 5 RVRSGIQAYALLQQLRA EKKAN 3 4 -I-NTEE QG	GQASEETKAKFDKVQKDLGFGLLLK
(B) Pasteurellales	(Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens	293390515 251793063 152979454 52424770	317 5 RVRSGIQAYALLQQLRA EKKAN 3	GQASEETKAKFDKVQKDLGFGLLLK 
(B) Pasteurellales	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemoohilus influenzae	293390518 251793063 152979454 52424770 145627968	317 RVRSGIQAYALLQQLRA EKKAN 	GQASEETKAKFDKVQKDLGFGLLLK 
(B) Pasteurellales (Clade 1)	(Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae	293390515 251793063 152979454 52424770 145627965	317 5 RVRSGIQAYALLQQLRA EKKAN 3	GGASEETKAKFDKVQKDLGFGLLLK GGASEETKAKFDKVQKDLGFGLLK GINE-TKSQFLNVREY QVNE-TKAQFLATRDY VNQ-NE-K
(B) Pasteurellales (Clade 1) 13/20	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus	293390515 251793063 152979454 52424770 145627965 170717520	317         RVRSGIQAYALLQQLRA         EKKAN         -I-N-TEE         QG        N-MVGEE         QRRE-FT         QN-MVG	GQASEETKAKFDKVQKDLGFGLLLK 
(B) Pasteurellales (Clade 1) 13/20	(Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis	293390515 251793065 152979454 52424770 145627965 170717520 260912906	317         RVRSGIQAYALLQQLRA         EKKAN	353 GQASEETKAKFDKVQKDLGFGLLLK 
(B) Pasteurellales (Clade 1) 13/20	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida	293390518 251793063 152979454 52424770 145627968 170717520 260912906 15602839	317           RVRSGIQAYALLQQLRA           EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD           -VNQ-NE-K           -VNQ-NA-KD           QVSE-TKAQFSAVSK           QUSE-TKAQFSAVSK
(B) Pasteurellales (Clade 1) 13/20	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida	293390515 251793063 15297945 52424770 145627965 170717520 260912900 15602839 29152700	317         AVRSGIQAYALLQQLRA         EKKAN	GGASEETKAKFDKVQKDLGFGLLLK           GINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K-          VNQ-NA-KD           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK
(B) Pasteurellales (Clade 1) 13/20	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi	293390516 251793063 152979454 52424770 145627968 170717520 260912900 15602839 33152792	317         RVRSGIQAYALLQQLRA         EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K-           -VNQ-NA-KD-           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           NYT-D-LA-Q-
(B) Pasteurellales (Clade 1) 13/20	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis	293390518 251793063 152979454 52424770 145627965 170717520 260912906 15602839 33152792 167855033	317         317         4       -I-NTEEQG        N-MVGEEQG         5      N-R-E-FTQG         6      N-MVGKQ         7      N-VDLQ         9      N-VG-EKS         9      N-VG-EKS	363         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NA-KD         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983	317         317           5         RVRSGIQAYALLQQLRA         EKKAN           4         -I-N-TEEQG         QG           5        N-MVGEE	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           -NYT-D-LA-Q
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica	293390518 251793063 152979454 52424770 145627965 170717520 260912906 15602839 33152792 167855033 116687983	317         RVRSGIQAYALLQQLRA         EKKAN        N-MVGEE         QG        N-MVGEKS        N-MVGEKS        KGEKS	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae	293390516 251793063 152979454 52424770 145627965 170717522 260912906 15602839 33152792 167855033 116687985 12620778	317         RVRSGIQAYALLQQLRA         EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD           -VNQ-NE-K           -VNQ-NE-K           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           -NYT-D-LA-Q           -NYT-AD-EA-KA           -NYTA-D-A-QAG
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948546	317           5         RVRSGIQAYALLQQLRA           6	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K-          VNQ-NA-KD           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           NYT-D-LA-Q           -NYT-AD-EA-KA           -NYT-DA-QAG           -NYT-DA-KA
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor Actinor	293390518 251793063 152979454 52424770 145627968 170717520 260912906 15602839 33152792 167855033 11668798 12620778 240948546 21315757	317           S         RVRSGIQAYALLQQLRA         EKKAN           A	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VN           QVSE-TKAQFSAVSK           QUSE-TKAQFSAVSK           OISE-TKAQFNAVSK           -NYT-D-LA-Q           -NYT-AD-EA-KA           -NYT-DA-QAG           -NYT-D-LA-Q
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 213157570	317         5       RVRSGIQAYALLQQLRA         6	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K           -VNQ-NA-KD           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           -NYT-D-LA-Q           -NYT-AD-EA-KA
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii	293390518 251793063 152979454 52424770 145627965 170717520 260912906 15602839 33152792 16785503 116687983 12620778 240948544 213157570 226944095	317         RVRSGIQAYALLQQLRA         EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K
<ul> <li>(B)</li> <li>Pasteurellales</li> <li>(Clade 1) 13/20</li> <li>Pasteurellales</li> <li>(Clade 2) 7/7</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila	293390516 251793063 152979454 52424770 145627965 170717522 260912906 15602839 33152792 167855033 116687985 12620778 240948544 213157570 226944095 11761780	317         RVRSGIQAYALLQQLRA         EKKAN	3653           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD           -VNQ-NE-K-           -VNQ-NE-K-           QVSE-TKAQFSAVSK           QISE-TKAQFNAVSK           -NYT-D-LA-Q           -NYT-AD-EA-KA           -NYT-AD-EA-KA           -NYT-D-A-AQAG           -NYT-D-A-KA           -DR-DL-R-R-E-KOY
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948546 213157570 226944093 11761780	317         RVRSGIQAYALLQQLRA         EKKAN	363         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NA-KD         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-K-KA         -NYT-D-A-KA         -NYT-D-Y         -NYT-P-LL-S-E-NY         -NK-P-KI-A-NE-KDY         -DK-P-NUOK
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis	293390518 251793063 152979454 52424770 145627965 170717520 260912906 15602839 33152792 167855033 116687983 12620778 240948546 213157577 226944093 11761780 237809443	317         RVRSGIQAYALLQQLRA         EKKAN        N-MVGEE         QG        N-MVGEE         QG        N-MVGEK         QG	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NA-KD
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 21315757 226944093 117617804 237809445	317         RVRSGIQAYALLQQLRA         EKKAN	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NE-K         -VNQ-NA-KD         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae	293390518 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948544 213157570 226944095 11761780 237809445 20965353 262276110	317         RVRSGIQAYALLQQLRA         EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacteri damselae	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687983 12620778 240948544 213157570 226944093 11761780 237809443 209695355 262276110 26913001	317         5       RVRSGIQAYALLQQLRA         6	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NE-K         -VNQ-NE-K         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         -NYT-D-LA-Q
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. minor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948546 213157570 226944093 11761780 237809444 209695355 262276110 269103012	317         RVRSGIQAYALLQQLRA         EKKAN	363           GQASEETKAKFDKVQKDLGFGLLLK           QINE-TKSQFLNVRE           QVNE-TKAQFLATRD          VNQ-NE-K
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. ninor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacteria	293390516 251793063 152979454 52424770 145627965 170717522 260912906 15602839 33152792 167855033 116687985 12620778 240948546 213157570 226944092 11761780 237809445 209695355 262276110 269103012 255745396	317         RVRSGIQAYALLQQLRA         EKKAN        N-MVGEE         QG        N-MVGEE         QG        N-MVGEE         QG	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         -VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFLATRD         QVSE-TKAQFSAVSK         QISE-TKAQFSAVSK         OISE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-KA         -DK-P-NI-A-D-K-W         -BKTP-NI-A-D-KH-Y         -EKTP-NI-A-D-K-Y         -BKTP-NI-A-D-K-Y         -BKTP-NI-A-C-K-Y         -BKTP-NI-A-C-K-Y         -BKTP-NI-A-E-KH-Y
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 21315757 226944093 11761780 237809445 209695355 262276110 269103012 255745396 71279876	317         5       RVRSGIQAYALLQQLRA         6	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         -VNQ-NE-K-         -VNQ-NE-K         -VNQ-NA-KD         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         OISE-TKAQFNAVSK         NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-KA         -NYT-D-A-KA         -DR-P-LL-S-E-NY         -NK-P-KI-A-NE-KDY         -NK-P-KI-A-D-KY         -NKP-NL-Q-LKV-Y         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-A-GAG         -NYT-D-A-A-KA         -NYT-D-A-A-KA         -NYT-D-A-A-KA         -DR-P-LL-S-E-NY         -NKD-R-R-R-E-KQY         -DK-DD-R-R-RCY         -NK-N-N
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella ducreyi Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea	293390516 251793063 152979454 52424770 145627968 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948544 213157570 226944099 11761780 237809448 209695355 262276110 269103012 255745399 71279876 14991224	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	363         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NA-KD         QVSE-TKAQFSAVSK         QISE-TKAQFSAVSK         QISE-TKAQFSAVSK         OISE-TKAQFSAVSK         NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-CAG         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-CAG         -NYT-D-A-KA         -DR-P-LL-S-E-NY         -BKTP-NI-A-NE-KDY         -BKTP-NI-A-D-KHY         -EKTP-NL-A-D-KY         -BKTP-NI-AE-KHY         -EKTP-NI-N-NETKH-Y         -EETP-NI-R-NETKH-Y
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Azotobacter vinelandii Actomonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Bauchemanac. ac CUNT2	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687983 12620778 240948544 213157570 226944093 11761780 237809443 209695355 262276110 269103011 255745396 71279876 149912244	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         6	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFSAVSK         QISE-TKAQFSAVSK         QISE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-KA         -DR-P-LL-S-E-N-         -DK-DO-R-R-E-KO-         -KKP-NI-A-D-KK-         -DKTD-R-R-E-KQ-         -DK-PNL-A-D-KH-         -DK-PNL-A-D-KH-         -DK-PNL-A-NE-KH-         -DK-PNL-A-NE-KH-         -DK-PNL-A-NE-KY-         -DKTP-NI-A-NE-KH-         -DK-PNL-A-N-K-         -DK-PNL-A-N-K-
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. ninor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 213157570 226944093 11761780 237809445 209695355 262276110 269103012 255745396 71279876 149912243 90408538	317         RVRSGIQAYALLQQLRA         EKKAN	3633         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NE-K
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. ninor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687985 12620778 240948544 213157570 226944093 11761780 237809444 209695355 262276110 269103012 255745396 71279876 149912243 90408538 119775484	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 167855033 116687983 240948544 21315757 226944095 117617800 237809445 209695357 262276110 269103012 255745399 71279876 149912245 90408538 119775484	317         5       RVRSGIQAYALLQQLRA         6	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella ducreyi Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. ninor Actinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri	293390516 251793063 152979454 52424770 145627968 170717520 260912900 15602839 33152792 16785503 116687983 12620778 240948544 213157570 226944099 11761780 237809448 209695355 262276110 269103012 255745399 71279876 149912244 90408538 119775484	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         8	363         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Azotobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter ium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 16785533 116687983 12620778 240948546 213157570 226944093 11761780 237809443 209695355 262276110 269103012 255745399 71279876 149912244 90408538 11977548- 157146644 24223859	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         OYSE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-KA         -DR-P-LL-S-E-N         -NK-P-KI-A-NE-KO         -NK-P-KI-A-D-KA         -DK-DD-R-RE-KO         -KTP-NL-A-D-KH         -KTP-NL-A-C-K+         -DK-P-NI-R-N-E-KO         -NYT-NN-AC-K+         -DK-P-NI-A-D-K+         -DK-P-NI-AD-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -DK-P-NI-AS-K+         -DK-P-NI-AC-K+         -DK-P-NI-AC-K+         -STDQAVRDQ-NN-K-         -NTDQAVRDE-N-NKQ-Y
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. pleuropneumoniae Act. ninor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae	293390516 251793063 152979454 52424770 145627963 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 213157570 226944093 11761780 237809445 209695355 262276110 269103012 255745396 71279876 149912243 90408538 119775484 157146644 242238594 299061711	317         RVRSGIQAYALLQQLRA         EKKAN	3633         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Azotobacter vinelandii Acromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia bilingiae Escherichia coli	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687985 12620778 240948544 213157570 226944093 11761780 237809445 209695355 262276110 269103011 255745396 71279876 149912243 90408538 11977548 157146644 24223859 299061711 407637	317         5       RVRSGIQAYALLQQLRA         EKKAN         3	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli	293390516 251793063 152979454 52424770 145627963 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948544 21315757 226944093 11761780 237809444 209695355 262276110 269103012 255745399 71279876 149912243 90408538 119775484 157146644 242238599 299061711 497637	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella ducreyi Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. ninor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae	293390516 251793063 152979454 52424770 145627965 170717520 260912900 15602839 33152792 16785503 116687985 12620778 240948546 213157570 226944099 11761780 237809445 209695355 262276110 269103011 255745396 71279876 149912244 90408538 119775484 157146644 242238594 299061711 497637 1926318	317         3         3         4       I-N-T	363         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD        VNQ-NE-K
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687983 12620778 240948544 21315757 226944093 11761780 237809449 20969535 262276110 269103012 255745399 71279876 149912244 90408538 11977548 15714664 24223859 299061711 497637 1926318 22633094	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. pleuropneumoniae Act. ninor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Providencia alcolifeciene	293390516 251793063 152979454 52424770 145627963 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948546 213157570 226944093 11761780 237809445 209695353 262276110 269103012 255745390 71279876 149912243 90408538 11977548 157146644 242238594 299061711 497637 1926318 226330943	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3633         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella multocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Azotobacter vinelandii Acromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri Providencia alcalifaciens	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687983 12620778 240948544 213157570 226944093 117617800 237809443 209695355 262276110 269103011 255745396 71279876 149912241 90408538 11977548 157146644 242238594 299061711 497637 1926318 226330943 21271244	317         5       RVRSGIQAYALLQQLRA         EKKAN         3	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFSAVSK         QISE-TKAQFSAVSK         QISE-TKAQFSAVSK         OJSE-TKAQFSAVSK         NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-AD-EA-KA         -NYT-D-A-CAQG         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -DK-DD-R-R-E-ENC-Y         -KKP-NI-A-D-KH-Y         -EKTP-NL-A-D-K-Y         -BK-P-NL-A-D-K-Y         -BK-P-NL-A-E-KH-Y         -BKTP-NL-AE-KH-Y         -BKTP-NL-AF-K-Y         -BKTP-NM-AE-KH-Y         -BKTP-NM-AK-Y
<ul> <li>(B)</li> <li>Pasteurellales (Clade 1) 13/20</li> <li>Pasteurellales (Clade 2) 7/7</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. ninor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri Providencia alcalifaciens Salmonella enterica	293390516 251793063 152979454 52424770 145627963 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948544 21315757 226944093 11761780 237809444 209695355 262276110 269103012 255745396 71279876 149912243 90408538 11977548 157146644 242238599 299061711 497637 1926318 226330942 21271244 161504096	317         317         317         317         317         317         317         317         317         317         317         317         311         3	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFSAVSK         QISE-TKAQFNAVSK         QISE-TKAQFNAVSK         NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-D-A-QAG         -NYT-D-A-CAG         -NYT-D-A-KA         -DR-P-LL-S-E-NY         -NK-P-KI-A-NE-KD-Y-         -DK-DD-R-R-E-KQ-Y-         -EKTP-NL-QELKV-Y-         -EKTP-NL-A-D-KY-         -BTP-NL-N-D-KH-Y-         -BTP-NL-A-D-KY-         -BTP-NL-A-D-KY-         -BTP-NL-A-D-KY-         -BTP-NL-A-D-KY-         -BTP-NL-ACKY-         -BTP-NL-NY-         -BTP-NL-NY-         -BTCDAVRDQ-NN-KY-         -NTDQAVRDE-N-NKO-Y-         -NKDPAURE-ND-KY-         -STDQAVRDQ-NSMKY-         -STDQAVRDQ-NSMKY-         -STDQAVRDQ-NSMKY-         -STDQAVRDQ-NSMKY-
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somus Pasteurella dagmatis Pasteurella dultocida (Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. ninor (Acinetobacter baumannii Azotobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Actobacter vinelandii Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri Providencia alcalifaciens Salmonella enterica	293390516 251793063 152979454 52424770 145627965 170717522 260912906 15602839 33152792 167855033 116687985 12620778 240948544 213157570 226944093 11761780 237809445 20969535 262276110 269103012 255745396 71279876 149912245 90408538 119775484 157146644 24223859 299061711 497637 1926318 226330945 212712444	317         3         3         4	3633         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K-         -VNQ-NE-K-         QVSE-TKAQFSAVSK         QISE-TKAQFSAVSK         QISE-TKAQFNAVSK         -NYT-D-LA-Q         -NYT-AD-EA-KA         -NYT-AD-EA-KA         -NYT-D-A-CAGG         -NYT-D-A-CAGG         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -NYT-D-A-KA         -DK-P-NI-A-D-K         -DK-P-NI-A-D-K         -DK-P-NI-A-D-K         -DK-P-NI-A-D-K         -DK-P-NI-AD-K         -DK-P-NI-AC         -DK-P-NI-AC         -DK-P-NI-AEAKI         -Y
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. minor (Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri Providencia alcalifaciens Salmonella enterica Serratia proteamaculans	293390516 251793063 152979454 52424770 145627963 170717522 260912906 15602839 33152792 167855033 116687983 12620778 240948544 21315757 226944093 11761780 237809449 20969535 262276110 269103012 255745399 71279876 149912244 90408538 11977548 15714664 24223859 299061711 497637 1926318 226330944 21271244 161504091 15736951	317         317         317         317         317         317         317         317         317         317         317         317         311         3	3853         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD
(B) Pasteurellales (Clade 1) 13/20 Pasteurellales (Clade 2) 7/7 Other Gamma Proteobacteria (0/500)	Agg. actinomycetemcomitans Agg. aphrophilus Act. succinogenes Man. succiniciproducens Haemophilus influenzae Haemophilus somnus Pasteurella dagmatis Pasteurella dultocida Haemophilus ducreyi Haemophilus parasuis Man. haemolytica Act. pleuropneumoniae Act. pleuropneumoniae Act. pleuropneumoniae Act. pleuropneumonia Act. pleuropneumonia Act. pleuropneumonia Act. pleuropneumonia Act. pleuropneumoniae Act. minor Acinetobacter baumannii Azotobacter vinelandii Aeromonas hydrophila Tolumonas auensis Aliivibrio salmonicida Grimontia hollisae Photobacterium damselae Vibrio cholera Colwellia psychrerythraea Moritella sp. PE36 Psychromonas sp. CNPT3 Shewanella amazonensis Citrobacter koseri Dickeya dadantii Erwinia billingiae Escherichia coli Klebsiella pneumoniae Proteus penneri Providencia alcalifaciens Salmonella enterica Serratia proteamaculans Shigella dysenteriae	293390516 251793063 152979454 52424770 145627963 170717520 260912900 15602839 33152792 167855033 116687983 12620778 240948544 21315757 226944093 11761780 237809445 209695353 262276110 265745396 71279876 149912243 90408538 11977548 157146644 242238599 299061711 497637 1926318 226330943 21271244 161504091 15736951 82776010	317         5       RVRSGIQAYALLQQLRA         6       RVRSGIQAYALLQQLRA         7       I-N-TEE	3653         GQASEETKAKFDKVQKDLGFGLLLK         QINE-TKSQFLNVRE         QVNE-TKAQFLATRD         -VNQ-NE-K

A clade consisting of the remaining Clade II species (all except H. parasuis) is strongly supported in the phylogenetic tree. We have identified three CSIs that are specific for this subclade of the Clade II. Information for one of these CSIs is presented in Fig. 5b, which shows a 5 aa insert in the enzyme tRNA-(uracil-5-)-methyltransferase. Similar to this CSI, a 2 aa insert in a highly conserved region of the ribosomal proteins S4 (Supplementary Fig. 53) and a 7 aa deletion in the enzyme adenylate cyclase is also specific for this subclade of the Clade II species (Supplementary Fig. 54). The genetic changes for these CSIs were likely introduced in a common ancestor of the remaining Clade II species after the branching of *H. parasuis*. In the enzyme DNA gyrase B, which contains a 2 aa insert specific for the Clade II species, in the same position where this insert is found, a 5 aa insert is also uniquely present in the two succinic acid producing bacteria Act. succinogenes and Man. succiniciproducens (Supplementary Fig. 51). The latter two bacteria form a strongly supported cluster in the phylogenetic tree and the shared presence of this insert support that they are specifically related (Fig. 1). The different lengths and species specificity of these inserts indicate that the genetic changes responsible for them occurred independently in the common ancestors of these two groups of Pasteurellales species.

#### Discussion

The members of the Order Pasteurellales are presently distinguished from other bacteria primarily on the basis of their distinct branching in phylogenetic trees (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). Furthermore, although this order is comprised of at least 15 genera, due to a lack of reliable information about their interrelationships, all of them are placed into a single family (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). We report here for the first time >60 molecular signatures that are distinctive characteristics of either all sequenced Pasteurellales species/strains or a number of welldefined subclades within this order. Of the signatures described here, 23 CSIs in widely distributed proteins are uniquely found in all of the sequenced Pasteurellales species/strains (Table 2) and they are not **Fig. 5** Partial sequence alignments for the proteins **a** DNA  $\blacktriangleright$  adenine methylase showing a 3 aa insert that is specific for Clade 2 Pasteurellales species and **b** tRNA (uracil-5-)-methyltransferase, showing a 5 aa insert, that is uniquely found in all Clade 2 species except *H. parasuis*, which is the deepest branching species in Clade 2 (Fig. 1). Other CSIs showing similar specificity are listed in Table 3B. The *dashes* in the sequence alignments indicate identity with the amino acid on the *top* line

found in any other bacteria. Due to their specificity to the Pasteurellales, the rare genetic changes responsible for them were likely introduced only once in a common ancestor of these bacteria and then passed on to various descendent species (Gupta 1998; Rokas and Holland 2000; Gupta and Mathews 2010). The presence of these CSIs in all Pasteurellales and their absence in all other bacteria strongly indicates that the genes for these proteins have not been laterally transferred from Pasteurellales to other bacterial groups or vice versa (Gogarten et al. 2002; Christensen and Bisgaard 2010). Thus, these CSIs provide potentially useful molecular markers (synapomorphies) for the identification and circumscription of species from the order Pasteurellales in molecular terms.

In addition to these CSIs that are uniquely found in all sequenced Pasteurellales, 21 other CSIs were identified that are also largely specific for this order of bacteria. However, in some of these cases the homologues for these genes/proteins were not detected in 1 or 2 Pasteurellales species, whereas in some others an isolated species from other bacterial groups was also found to contain these CSIs. Because these CSIs are commonly present in all (or most) Pasteurellales, with only isolated exceptions showing no specific pattern, it is highly likely that the genetic changes responsible for them also occurred in a common ancestor of the Pasteurellales. This was likely followed by loss of the genes from a few species and their acquisition by isolated species from other groups by LGTs (Gogarten et al. 2002). However, the possibility that sequence information for some of these observed exceptions might be incorrect in the public databases cannot be entirely ruled out.

All of the genera within the order Pasteurellales are currently placed into a single family, *Pasteurellaceae* (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). However, the present work has also identified many CSIs that are

· • •		1	60	196
(A)	/Haemophilus ducrevi	33151643	KAQKAQFICADFEHIFEYI	YQN PDNYIVYCDPPYAPL
× /	Haomonhilus narasuis	167855501	HOV-O-I	
Destourollolos		107035331		
rasteurenaies	Act. pieuropneumoniae	165975648	EQV-ARL	A
(Clade 2)	Act. minor	240949520	QV-A-L	REK N
7/7	Man, haemolytica	254360599	T-VQVLA	KN0 1 TD-VT
///	Agg actingmustersomitors	061067160		
	Agg. actinomycetemcomitans	20100/102		DE-3V1
	Agg. aphrophilus	251793891	S-VQQT-QMA	DE-SVI
	Man. succiniciproducens	52426022	KS-VNET-KLA	D-ESVI
	Act succinogenes	152977947	S-VGOFT-11A	DEHSVT
Pasteurellales <	Bestevenelle demotie	000010710		DE OVI
(Clade 1)	Pasteurella dagmatis	260912712	N-1AII-ALA	DE-5V11
(Clade I)	Pasteurella multocida	15603087	N-EQQT-SLA	DEKS-I
13/20	Haemophilus somnus	170717279	R-VQQA-SM-	NNDSVI
	Haemonhilus influenzae	145628517	S-V-L-COKTFA	
		143020317		
	Aeromonas nydropnila	67483065	ESTADAIQRA	EEDWVI
	Tolumonas auensis	237809354	T-V-QS-MET-AML	EQDHVV
	Photobacterium profundum	90413591	KR-T-V-EGYQQT-SRA	RKGCV
	Grimontia bollisae	262273420	KT-V-ESVPOS-KBA	BRGSVT
		202270420		00001
	vibrio cnoierae	254226801	R-ISYGEI-ARA	QSDSVI
	Idiomarina loihiensis	56461575	RKRPQV-RRA	RQGDVI
	Shewanella baltica	126176295	R-E-K-IGY-KAQT	RSGDV
	Ancononhonus, naconico	284008883		NKSSVT
	Ar senophonus hasonitae	204000000		11(00)
<b>A1 A</b>	Candidatus Hamiltonella	238898717	N-IENYQQILMQA	SGRAV V
Other Gamma	Citrobacter koseri	157148970	N-E-H-LSY-ECMDRA	DS-SV
Proteobacteria	Dickeva zeae	251787913	N-T-V-EHYQQTLTNA	TSGSV
1 I otcobacter na	Eachanishia aoli	000024240		HACDV
(0/500)	Escherichia coli	222034349	RATAS-DETLAML	HAGDV
	Enterobacter cloacae	295097003	N-E-Y-LSY-ECMDLA	GV-SV
	Klebsiella pneumoniae	206579011	N-E-Y-ESY-ECMQRA	DSRAV
	Proteus mirabilis	227354957	I-V-OSYSSTMTNA	TKGSV
	Drovidencie stuentij	102600600		ECCEV
	Providencia stuartii	103000009		E303V
	Xenorhabdus bovienii	290473145	S-V-QHYQ11LDNA	-QGSV1
	Yersinia bercovieri	238783119	-S-H-V-V-EHYQETLLKA	VQGAV
	Legionella pneumophila	52842289	EE-KYSV-MGEA	IKGDVV
	Nitrococcous halophilus	202402400		
	WILLOSOCOCCUS Halophilus	292493400		hidi VAV
			42	77
<b>(B)</b>	deemenhilus duenevi	22151905		
<b>(B)</b>	(Haemophilus ducreyi	33151895	42 RMRAEFRVWHQ KNEQG	77 ENDLYHIMFDPTTKQRYRVD
(B) Pasteurellales .	Haemophilus ducreyi Act. minor	33151895 223041752	42 RMRAEFRVWHQ KNEQG DK-	77 ENDLYHIMFDPTTKQRYRVD EE
(B) Pasteurellales .	Haemophilus ducreyi Act. minor Act. pleuropneumoniae	33151895 223041752 32034047	42 RMRAEFRVWHQ KNEQG DK- D TV-	77 ENDLYHIMFDPTTKQRYRVD EEC-E
(B) Pasteurellales . (Clade 2)	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act succinogenes	33151895 223041752 32034047 152978112	42 RMRAEFRVWHQ KNEQG DK- D TV- X5-NB	77 ENDLYHIMFDPTTKQRYRVD EE EQEC-E GGNK
(B) Pasteurellales . (Clade 2) 6/7	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes	33151895 223041752 32034047 152978112	42 RMRAEFRVWHQ KNEQG DK- D TV- LD YS-NR	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis	33151895 223041752 32034047 152978112 219872016	42 RMRAEFRVWHQ KNEQG DK- D TV- D YS-NR -LD	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK NGQA
(B) Pasteurellales - (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae	33151895 223041752 32034047 152978112 219872016 145628253	42 RMRAEFRVWHQ KNEQG DK- D TV- D <u>YS-NR</u> -LD	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNKNGQA-LK
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus	33151895 223041752 32034047 152978112 219872016 145628253 170718062	42 RMRAEFRVWHQ KNEQG DK- D TV- -LD YS-NR -LD E	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK NGQA-LK QD-FQKF-I
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man haemolytica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651	42 RMRAEFRVWHQ KNEQG DK- D TV- D YS-NR -LD I-E F	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK NGQA-LK QD-FQKF-I 
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651	42 RMRAEFRVWHQ KNEQG DK- D TV- D YS-NR -LD E E	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> →	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475	42 RMRAEFRVWHQ KNEQG DK- D TV- -LD YS-NR -LD IE E E	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK NGQA-LK QD-FQKF-I -GEN-E-A QD-FQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563	42 RMRAEFRVWHQ KNEQG DK- D TV- D D 	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK NGQA-LK QD-FQKF-I- -GEN-E-A QD-FQQS GD-FQQS
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> → Pasteurellales (Clade 1)	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579	42 RMRAEFRVWHQ KNEQG DK- D TV- YS-NR -LD IE E E E E IE IE IE	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK
(B) Pasteurellales . (Clade 2) <sup>6/7</sup> → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668	42 RMRAEFRVWHQ KNEQG DK- D YS-NR -LD IE IE E E IE IE IE IE IE	77 ENDLYHIMFDPTTKQRYRVD EQEC-E GGNK QD-FQA-LK QD-FQKF-I -GEN-E-A QD-FQQS- GD-FQQS- GG-FQR KG-FQR
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales . (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNK NGQA-LK QD-FQKF-IGEN-E-A QD-FQQS GD-FQQS GG-FQQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422	42 RMRAEFRVWHQ KNEQG DK- D YS-NR -LD I-E I-E E E E E E E E E E E E E E E	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQA QD-FQA-LK QD-FQKF-I
(B) Pasteurellales - (Clade 2) 6/7 → Pasteurellales - (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352	42 RMRAEFRVWHQ KNEQG D D D D D D D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQA-LK QD-FQA-LK QD-FQS QD-FQQS GD-FQQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNK NGQA-LK QD-FQKF-IGEN-E-A QD-FQQS GD-FQQS GG-FQQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 2692103682	42 RMRAEFRVWHQ KNEQG D D D D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQA
(B) Pasteurellales - (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 269103682	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNK
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 2933914579 15603668 52426422 117621352 262273152 269103682 229527105	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQA QD-FQA-LK QD-FQA-LK QD-FQQS GD-FQQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 269527105 85711838	42 RMRAEFRVWHQ KNEQG D D D D D D D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQA-LK QD-FQA-LK QD-FQQS GD-FQQS GD-FQQS
(B) Pasteurellales - (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 269103682 229527105 85711838 119944400	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQA-LK QD-FQA-LK QD-FQA-LK QD-FQQS GD-FQQS
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269103682 229527105 85711838 119944400 11977334	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQA QD-FQA-LK QD-FQKF-IGEQR GD-FQQ-R
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269273152 269273152 269103682 229527105 85711838 119944400 119773334	42 RMRAEFRVWHQ KNEQG 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
(B) Pasteurellales - (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dultocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 269103682 229527105 85711838 119944400 119773334 284009190	42 RMRAEFRVWHQ 	77 ENDLYHIMFDPTTKORYRVDEQEC-E GGN
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 217621352 269273152 269103682 229527105 85711838 119944400 11977334 284009190 157147235	42 RMRAEFRVWHQ D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQA
(B) Pasteurellales . (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269273152 269103682 229527105 85711838 119944400 11977334 284009190 157147235 251787782	42 RMRAEFRVWHQ D D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
(B) Pasteurellales - (Clade 2) 6/7 → Pasteurellales (Clade 1) 13/20	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dultocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269103682 229527105 85711838 119944400 119773334 284009190 157147235 251787782 238921674	42 RMRAEFRVWHQ 	77 ENDLYHIMFDPTTKORYRVDEQEC-E GGN
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dultocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 229527105 85711838 119944400 119773334 284009190 157147235 251787782 238921674	42 RMRAEFRVWHQ D D D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQEC-E GGNQA-LK QD-FQA-LK QD-FQKF-IGEQR GD-FQR
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 26910368 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348	42 RMRAEFRVWHQ D D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dugmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269273152 269103682 229527105 85711838 119944400 119773334 284009190 157147235 251787782 238921674 296105348 188532302	42 RMRAEFRVWHQ 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQEC-E GGNQA QD-FQA
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188532302 188496220	42 RMRAEFRVWHQ D D D D D D E D D D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQEC-E GGNQA-LK QD-FQA-LK QD-FQA-LK QD-FQQS GD-FQQS GD-FQQS GD-FQQS
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 26910368 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188552302 188496220	42 RMRAEFRVWHQ D D D D D D E 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dugmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 217621352 269273152 269103682 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188532302 188496220 206578514	42 RMRAEFRVWHQ D D D D D D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GRN
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 229527105 85711838 119944400 157147235 251787782 238921674 296105348 188532302 188496220 206579514	42 RMRAEFRVWHQ D D D D D E D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNKQEC-E GGNQA-LK QD-FQA-LK QD-FQA-LK QD-FQQS GD-FQQS
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 26910368 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188522302 188496220 206579514 227354694 188025467	42 RMRAEFRVWHQ 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 217621352 269103682 229527105 85711838 119944400 157147235 251787782 238921674 296105348 188532302 188496220 206579514 227354694 188025467 161505380	42 RMRAEFRVWHQ D D D D D D D E D E E E E E D D D E E E D	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQAQA
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 229527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188532302 188496220 206579514 227354694 188025467 161505380 8277885	42 RMRAEFRVWHQ D D D D D D E D E E D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGN
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dugmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269273152 269273152 269103682 229527105 85711838 119944400 119773334 284009190 157147235 251787782 238921674 296105348 188532302 188496220 206579514 188025467 161505380 82778552	42 RMRAEFRVWHQ 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQEC-E GGNQKF-IGEQKF-IGEQKF-IGEQK
<ul> <li>(B)</li> <li>Pasteurellales .</li> <li>(Clade 2)</li> <li>6/7</li> <li>Pasteurellales .</li> <li>(Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dugmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica Shigella dysenteriae Sodalis glossinidius	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269103682 229527105 85711838 119944400 157147235 251787782 238921674 296105348 188532302 188496220 206579514 227354694 188025467 161505380 82778852 85060132	42 RMRAEFRVWHQ D D D D D D E D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GGNQEC-E GGNQA
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella multocida Man. succiniciproducens (Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica Shigella dysenteriae Sodalis glossinidius Xenorhabdus bovienii	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 269273152 269273152 269273152 269273152 269273152 269527105 85711838 119944400 11977334 284009190 157147235 251787782 238921674 296105348 188532302 188496220 206579514 227354694 188025467 161505380 82778852 85060132 290477206	42 RMRAEFRVWHA 	77         ENDLYHIMFDPTTKQRYRVD        EQEC-E         GGNK
<ul> <li>(B)</li> <li>Pasteurellales - (Clade 2)</li> <li>6/7 →</li> <li>Pasteurellales - (Clade 1)</li> <li>13/20</li> <li>Other Gamma Proteobacteria (0/500)</li> </ul>	Haemophilus ducreyi Act. minor Act. pleuropneumoniae Act. succinogenes Haemophilus parasuis Haemophilus influenzae Haemophilus influenzae Haemophilus somnus Man. haemolytica Agg. Actinomycetemcomitans Agg. aphrophilus Pasteurella dagmatis Pasteurella dugmatis Pasteurella multocida Man. succiniciproducens Aeromonas hydrophila Grimontia hollisae Photobacterium damselae Vibrio cholerae Idiomarina baltica Psychromonas ingrahamii Shewanella amazonensis Arsenophonus nasoniae Citrobacter koseri Dickeya zeae Edwardsiella ictaluri Enterobacter cloacae Erwinia tasmaniensis Escherichia coli Klebsiella pneumoniae Proteus mirabilis Providencia stuartii Salmonella enterica Shigella dysenteriae Sodalis glossinidius Xenorhabdus bovienii Yersinia aldovae	33151895 223041752 32034047 152978112 219872016 145628253 170718062 261494651 293391475 251793563 260914579 15603668 52426422 117621352 262273152 269103682 229527105 85711838 119944400 11977334 284009190 157147235 251787782 28921674 296105348 188532302 188496220 206579514 188532302 188496220 206579514 18852467 161505380 82778852 85060132 290477206 238760129	42 RMRAEFRVWHQ D D D D D D E D E D 	77 ENDLYHIMFDPTTKQRYRVDEQEC-E GRNKQEC-E GRNQA

clades
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Conserved
Table 3

Protein name	Gene name	Accession no.	Figure no.	Indel size	Indel position <sup>a</sup>	Functional categories
(A) Conserved indels that are specific for the	he Clade I Pasi	teurellales				
Glutamyl-tRNA reductase <sup>b</sup>	hemA	NP_245621	Fig. 3a	4 aa ins	223–264	Coenzyme transport and metabolism
Long-chain-fatty-acid-CoA ligase <sup>b</sup>	fadD	YP_001344411	Fig. 3b	2 aa ins	222–274	Lipid transport and metabolism
Ribosomal protein S1	rpsA	YP_003006866	Fig. 4a	8 aa del	462-503	Translation
Cytochrome D ubiquinol oxidase subunit 1	cydA	ZP_06634849	Fig. 4b	5 aa ins	317-363	Energy production and conversion
Glucose-6-phosphate isomerase	pgi	ZP_05920623	Supplementary Fig. 41	1 aa ins	351-384	Carbohydrate transport and metabolism
TldD protein	tldD	YP_087972	Supplementary Fig. 42	2 aa ins	75-127	General function prediction only
Acriflavin resistance protein	acr	YP_001343841	Supplementary Fig. 43	1 aa del	111-154	Defense mechanisms
Guanylate kinase	gmk	YP_003007858	Supplementary Fig. 44	1 aa ins	51-105	Nucleotide transport and metabolism
GTP-binding protein EngA	engA	YP_003255506	Supplementary Fig. 45	1 aa ins	93-128	General function prediction only
Thiamine-monophosphate kinase	thiL	YP_001344779	Supplementary Fig. 46	2 aa ins	190–230	Coenzyme transport and metabolism
Fumarate reductase iron-sulfur subunit <sup>c</sup>	frdB	YP_003007744	Supplementary Fig. 47	11 aa ins	117-165	Energy production and conversion
Cell division protein FtsZ <sup>d</sup>	ftsZ	YP_001345210	Supplementary Fig. 48	3 aa ins	239–276	Cell cycle control, mitosis and meiosis
Lysyl-tRNA synthetase <sup>e</sup>	lysS	YP_001290934	Supplementary Fig. 49	2 aa ins	316-366	Translation
(B) Conserved indels that are specific for the	he Clade II Pas	steurellales				
Glutamyl-tRNA Reductase <sup>b</sup>	lemA NP	_245621	Fig. 3a	2 aa ins	223–264	Coenzyme transport and metabolism
Long-chain-fatty-acid-CoA ligase <sup>b</sup> fa	adD YP	-001344411	Fig. 3b	1 aa ins	222–274	Lipid transport and metabolism
DNA adenine methylase d	lam NP	_872996	Fig. 5a	3 aa ins	160-196	Replication, recombination and repair
tRNA (uracil-5-)-methyltransferase <sup>f</sup> tı	rmA NP	_873248	Fig. 5b	5 aa ins	42–77	Translation
S-ribosyl-homocysteinase lı	uxS NP	_872951	Supplementary Fig. 50	1 aa ins	85-137	Signal transduction mechanisms
DNA gyrase subunit B	tyrB YP	-001343447	Supplementary Fig. 51	2 aa ins	281–326	Replication, recombination and repair
Cysteine desulfurase is	scS NP	_873559	Supplementary Fig. 52	2 aa ins	274–319	Amino acid transport and metabolism
Ribosomal protein S4 <sup>f</sup> r]	psD ZP	-00134833	Supplementary Fig. 53	2 aa ins	22–51	Translation
Adenylate cyclase <sup>f</sup> c.	yaA NP	_873154	Supplementary Fig. 54	7 aa del	175–221	Nucleotide transport and metabolism
<sup>a</sup> The indel position indicates the regions o	of the proteins	where CSIs are pre	sent			

<sup>b</sup> Homologous sequences corresponding to this region could not be identified in *H. ducreyi* 

° The CSI is also found in H. parasuis of Clade II

 $^{\rm d}$  The CSI is also found in Man. haemolytica of Clade II

<sup>e</sup> One H. somnus strain was found without indel

 $^{\rm f}$  The CSI is not found in H. parasuis

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Fig. 6 A summary diagram showing the distribution patterns of various Pasteurellalesspecific CSIs indicating the evolutionary relationships among Pasteurellales species. The different clades within this order that are supported by both phylogenetic studies and the identified molecular signatures are shown



specific for two distinct clades of Pasteurellales, which are also supported by our phylogenetic analyses (Fig. 1) and that of others (Gioia et al. 2006; Redfield et al. 2006; Bonaventura et al. 2010). The first of these clades, supported by 13 CSIs (Table 3A), includes Aggregatibacter and Pasteurella species and also Act. succinogenes, Man. succiniciproducens and various strains of H. influenzae and H. somnus. The remaining Pasteurellales species (viz. Act. pleuropneumoniae, Act. minor, H. ducryi, Man. haemolytica and H. parasuis) formed the second clade, which was supported by nine uniquely shared CSIs (Table 3B). Within Clade II, several CSIs also supported the deeper branching of H. parasuis in comparison to other species. The mutually exclusive presence of many of these CSIs in species from these two clades make a persuasive case that these clades are evolutionarily distinct and the genetic changes responsible for these CSIs were introduced in their common ancestors as indicated in Fig. 6. It should be noted that in contrast to numerous CSIs that supported the existence of these two clades, we have not come across significant numbers of CSIs that support any other alternative clades. Therefore, the identified CSIs, independently of phylogenetic analyses, provide strong evidence for the existence of these two Pasteurellales clades. We suggest that these two Pasteurellales clades, whose existence is supported by both phylogenetic analyses and by many discrete molecular signatures, should be recognized as distinct higher taxonomic groupings (i.e. families) within this order.

Sequence information for all of the identified CSIs is presently limited to only those Pasteurellales species/strains, whose genomes have been sequenced. Hence, to fully understand the evolutionary and taxonomic significance of these CSIs, it is of much importance to obtain sequence information for them from other Pasteurellales species, notably including the appropriate type strains. For the CSIs that are specific for all Pasteurellales, due to their exclusive presence in all sequenced species/strains from this order and no other (>1500) prokaryotic or eukaryotic organisms, it is highly likely that they will also be present in other Pasteurellales species/strains for whom no sequence information is presently available. Our earlier work on many CSIs for other prokaryotic groups indicates that the CSIs of this kind have a high degree of predictive ability (Griffiths and Gupta 2002; Gupta 2005; Gao and Gupta 2005; Griffiths and Gupta 2006; Gupta 2009) and many of them will provide reliable molecular markers for the entire Pasteurellales order as sequence information for other species becomes available. However, for those CSIs that are specific for the two subclades of Pasteurellales, further studies to obtain sequence information from additional species/strains should be very informative. Based upon the presence or absence of the CSIs that are specific for the two subclades, it should be possible to assign/place other species into these subclades. This should help in determining more clearly the taxonomic boundaries of these two subclades. It is also possible that some species of Pasteurellales may be lacking both Clades I and II specific CSIs. This would suggest that such species might be parts of other higher taxonomic clades within the order Pasteurellales that have yet to be identified.

The Pasteurellaceae species are important human and animal pathogens and new species related to them are continually being discovered (Christensen and Bisgaard 2010). The identification of these medically important bacteria at present primarily relies upon culture-based nutritional and phenotypic characteristics (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). However, such tests are unable to reliably distinguish members of Pasteurellales species from some other orders of Gammaproteobacteria (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). In this context, the Pasteurellalesspecific CSIs described here provide a novel means for the identification of these bacteria. Degenerate PCR primers based on conserved regions of these CSIs-containing genes, should provide novel and specific means for the detection of both previously known as well as novel Pasteurellales species (or isolates) in different environments.

In the present study, our focus has been mainly on identifying CSIs that are specific for either all Pasteurellales or its larger clades. Although our work has identified many CSIs of these kinds, further detailed studies on other Pasteurellales genomes could lead to identification of additional signatures of this kind. In the present work, we have not analyzed CSIs that were specific for individual species/genera or for the smaller clades of Pasteurellales. We have also not yet looked for the presence of signature proteins (CSPs) that are specific for either all Pasteurellales or its different subgroups. Such studies will form the focus of our future work. A number of Pasteurellales genera (viz. *Haemophilus, Actinobacillus* and *Mannheimia*) are not monophyletic and it is important to develop reliable means to reorganize them (Olsen et al. 2005; Christensen and Bisgaard 2006; Christensen and Bisgaard 2010). The identification of large numbers of CSIs and CSPs those that are specific for individual species or smaller clades, in addition to their diagnostic values, should prove very helpful in the reorganization and circumscription of various Pasteurellales genera.

Most of the CSIs identified in this work are present in conserved regions of various proteins that are involved in wide variety of essential cellular functions. Our recent work on a number of CSIs in the GroEL and DnaK proteins show that these CSIs are essential for the group of organisms where they are found (Singh and Gupta 2009). Any deletions or significant changes in them lead to failure of cell growth, indicating that they are playing essential roles in these organisms (Singh and Gupta 2009). Based upon these observations and the evolutionary conservation of these CSIs for the Order Pasteurellales, it is expected that these CSIs also play important (and possibly essential) functional roles in these bacteria. Hence, further studies on understanding the cellular functions of these CSIs could provide important insights into novel genetic, biochemical and physiological characteristics of members of Pasteurellales or their different clades.

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