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# **Editorial Note**

The Interdisciplinary Research Review (IRR) was established with academic cooperation by the Nakhon Pathom Rajabhat University, The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group), and Rajamangala University of Technology Rattanakosin. This Issue, Volume 17 Number 1 (January – February 2022). This issue contains of four interesting articles in multidisciplinary fields: (1) New evidence from eye-tracking on how young adult Chinese speakers process Chinese and English words when reading, (2) The origin and evolution of Coronavirus pandemic in health science approach and Islamic perspectives, (3) Politics of reconciliation and new local governance based on Sufficiency Economy Philosophy and the King Rama IX's Working Philosophy: Case studies of local administrative organizations in the eastern region of Thailand, and (4) Assessment of genetic diversity of Wua-lan in Thailand.

The Editorial Board of the IRR encourages anyone to submit articles for evaluation and review. The processes of submission, review and publication of articles are described on the journal's website, https://www.tcithaijo.org/index.php/jtir. The Editorial Board and Committees of the IRR sincerely thank all peer reviewers who have sacrificed their time to help us produce a better journal, and also wish to thank all teachers, researchers and other academicians for submitting their valuable research to this journal. Finally, we thank readers of our journal who help to spread the knowledge and benefits gained to others. With your feedback and suggestions, we will strive to improve the quality and relevance of the IRR.

> Yongyudh Vajaradul Editor Interdisciplinary Research Review

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# New evidence from eye-tracking on how young adult Chinese speakers process Chinese and English words when reading

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# Abstract

Past research reveals the relevance of two routes for reading word recognition (direct/graphic and indirect/graphophonological). Choice of route is especially influenced by the writing system of the language, how word reading is taught, and for second languages, the first language processing route and level of second language exposure. However, the continuing effect of early instruction at a later age, and its impact relative to the other factors, have not been fully revealed. This study, therefore, examined those factors in L1 Chinese and L2/L3 English reading by university students in Hong Kong and Taiwan, exploiting the fact that early reading instruction is in both languages predominantly 'whole word' in Hong Kong versus 'phonic' in Taiwan. University participants in Hong Kong and Taiwan responded to a true/false judgment task using sentences containing contextually incongruent words that were phonologically or graphically similar to contextually congruent words. Accuracy and eye-tracking data were gathered. Only writing system effect was significant: the route favoured by the writing system prompted differential fixation time on the target word, and differential accuracy (F= 10.94, p=.004, partial eta squared=.354). The lack of enduring word reading instruction effect suggests that teachers need not limit themselves exclusively to either phonics or whole word instruction.

Keywords: L1 and L2 reading, two routes for reading, eye-tracking, writing system effect, instruction effect, awareness

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# 1. Introduction

The low level reading processes of written word recognition have long been a focus of attention in first language reading research, and to a lesser extent in L2 reading research. In particular, two 'routes' [1] have been posited through which a reader gets from a written word to its meaning when silently reading (which is our focus of attention). The direct route proceeds from writing to meaning by recognising the whole word shape (lexical or graphic route, GR) [2]; the indirect route proceeds via the sound, typically using sound correspondences of parts of the written word (phonological or grapho-phonological route, PR) [3] [4]. Today it is recognised that typical readers use both routes in varying degrees and with links between them at various points, depending on a range of factors [5] [6].

Associated with this, teaching methods have been designed that encourage one or the other route (whole word / 'look and say' teaching for GR, versus 'phonics' for PR) [7] [8]. The latter method might also involve using some kind of symbols representing the sounds in a more one to one way (e.g. for English the Initial Teaching Alphabet, the International Phonetic Alphabet, the pictorial icons of Visual Phonics, or in Taiwan the Kenyon and Knott (KK) transcription system; for Chinese alphabetic Pinyin in mainland China and syllabic Zhu-Yin-Fu-Hao in Taiwan). While both approaches involve the triad of written form, sound and meaning, sound is treated as far more essential to the acquisition and process of word recognition in the second than the first. The relative merits of the two approaches have been hotly debated in the L1 context [9] although not typically based on research that measures the extent to which each route is actually used.

This is all equally relevant to L2 teaching and reading, and the purpose of the present study is to further illuminate four aspects of this balance between the GR and PR that are particularly relevant to English as a foreign language reading, and have not been so well studied. In doing so it exploits a method of data gathering that has recently gained in popularity due to its increased availability to ordinary researchers, though it is still not widely used in this research domain - eyetracking. The core issues are: (a) whether in L1 or L2 reading the teaching method actually has any long term effect on the preferred route, in contrast with (b) the nature of the writing system of the language being read, and whether in L2 reading the preferred route is also impacted either by (c) the L1 or (d) the amount of experience of L2 reading. In effect, these issues rep-

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resent, in the specific domain of word reading, some of the most basic issues in SLA - i.e. the effects of instruction, L1 transfer, and L2 exposure.

#### 2. Literature review

The way in which a person processes written words has been widely found to be influenced by the nature of the writing system of the language being read. In the early days, a large difference was expected between writing systems that directly represent the sounds of the language, such as the alphabet used for Spanish as well as, to a lesser extent, that for English, and those that only give rather weak indications of the sound, such as the logographic characters used for Chinese. The original Dual Route model [10] predicted speakers of the former employing the PR and those of the latter the GR. It soon emerged, however, that competent readers in any language use both routes [11], and that phonological processing is universally available to all readers regardless of their writing system background, which even applies to readers with Chinese as L1 [12] who can then, in fact, learn English as L2 more successfully as a result of it. Nevertheless it remains open for readers to employ different balances of reliance on PR and GR when they read, and brain research has continued to show some differences for example between processing of English and Chinese words [13].

The effect of instruction on the degree of use of this or that route has been rather less investigated. Research on phonics teaching for example documents that the PR is used in class at a conscious level as part of the phonics instruction but does not typically research how much the PR is being relied on spontaneously later in silent reading. Instead, the later measures are usually of reading comprehension or 'word naming' (i.e. reading a word aloud) neither of which directly reveal the extent of the reader's reliance on the PR or GR [9]. It is of course a matter of debate how far instruction is expected to change what the learner does. It is a well-known feature of Krashen's [14] ideas that explicit teaching of grammar does not have a lasting impact, and this would apply also to the teaching of phonics or indeed look and say word processing. Nevertheless, Scholfield and Chwo [15] demonstrated an instructional effect on word reading route preference by 12-year-olds in Taiwan and Hong Kong. In the former, phonics-type approaches are used to teach initial reading both in L1 Chinese and L2/L3 English while in the latter 'look and say' or 'whole word' is more prevalent in both. This was reflected in significantly greater use of the PR than GR in Taiwan and of the GR in Hong Kong when reading words in both languages. It is an aim of the present study to see if a similar finding will be obtained with older participants, who are much further distant from the time when they received the differential type of instruction.

When we consider reading in a language other than L1, of course the above factors affecting route preference might be supplemented by others. First, transfer of L1 route preference to L2 is a possibility, and would be more noticeable where the writing system type is very different in each language (e.g. L1 Chinese, L2 English). L1 effect on L2 decoding has indeed often been reported [16] [17]. Second, there could be an effect of extent of experience of reading in the L2. In Scholfield and Chwo [6], this produced a difference in response time regardless of the route but not a route preference. The response was faster in Hong Kong than Taiwan, which was deemed explicable from the greater role of English in daily life in the former.

All the cited studies needed in some ways to measure readers' use of the PR and the GR. This presupposes that one can measure the route that a person uses to access word meaning from orthography when silently reading. One common approach, which we adopt, has exploited word pairs that differ in graphic and phonological similarity [15] [18]. If the GR is used, it is assumed that the reader will be more susceptible to confusion when they read words which are similar to each other in written form but not sound (e.g. English weight, height; the second character in Chinese 稻殻 and 稻穀 respectively dào qiào and dàogǔ in Pinyin). If the PR is followed then they will be more confused when they read words which are similar in sound but not written form (e.g. English write, right; second character in Chinese 公巾 and 公斤 both gōngjīn). Tasks are then devised to measure the degree of confusion. Stimuli might be graphically or phonologically similar word pairs which have to be judged for being similar or not in meaning. Alternatively sentences are created where words that make sense have been substituted by other graphically or phonologically similar words and the sentence has to be judged for truth. Response measures include time taken to respond (latency), the number of items completed in a given time, and brain activity [19] as well as secondarily the error rate of response. In the present study, the stimulus type is words in sentences as just described, and the primary response measure is eye fixation time, supplemented by the error rate in truth judgment. In our case, when participants encounter a word that does not make sense in a sentence, we are interested in whether their gaze dwells on it longer if it is similar in sound to the correct word or similar in written form.

Eye-tracking as a means of gathering data about reading in fact has quite a long history going back to the 19th century [20]. In psychology it used to require a specialist lab with burdensome equipment to be attached to the participant. Today however it has become much more widely accessible in computerised form where eye movements can be tracked without attaching anything to the participant. With respect to reading, eye-tracking has obvious advantages over other means of researching the unconscious processes that underlie it. In particular it enables us to measure time spent looking at particular words or parts of what is read (called fixation time), not just time spent reading a whole word, or sentence etc. [21]. An assumption is made that time spent on a particular part reflects mental processing of that part and not others [22].

As Jarodzka and Brand-Gruwel [23] admit, eyetracking is mostly used to study the low level reading process, within words and sentences. Nevertheless, we have not found any study of the two routes using eye-tracking. The closest seems to be Yip and Zhai [24] which, although not addressing the two routes, does involve Chinese and words which sound the same but have different meanings and written forms (homophones). They also included some partial homographs (e.g. shīzi: 狮子/虱子) but they were not separately examined. The authors in fact conclude by saying that it would be useful to look at homographs in parallel with homophones, which the present study does.

## 3. Methodology

The study has three independent variables: location of university-level participant (Hong Kong vs Taiwan); language that is read (L1/L2 Mandarin Chinese vs L2/L3 English); item interference type (graphic vs phonological similarity). Note that for many speakers in Hong Kong, Mandarin Chinese is strictly a second language after Cantonese while in Taiwan it is often a second language after Taiwanese or Hakka in terms of order of learning. The dependent variables are numbers of correct and erroneous judgments made about the truth of sentences and the eye-tracking measure of percent of time spent focused on the word that was either graphically or phonologically confusing, thus indicating preference for GR or PR. Together this design allows us to answer four questions, corresponding to the aims of the study declared at the start:

1. Is there an enduring effect of earlier instruction? The PR is encouraged in early teaching more than GR in Taiwan for both Chinese and English; the GR is favoured in Hong Kong for both languages.

2. Is there a writing system effect? The GR is favoured by Chinese, PR by English, regardless of country. Note that both places use the same traditional forms of the Chinese characters so there is no possible difference based on that.

3. Is there an L1 transfer effect of (b)? The GR would then be preferred not only for Chinese but also for English.

4. Is there an L2 exposure effect of (b)? Arguably the PR would be preferred for English more in Hong Kong than Taiwan due to greater experience of reading in English.

#### 3.1 Participants and their background

All participants were studying at the tertiary level, through the medium of Chinese. They were volun-

teers paid to participate in this experiment. In Hong Kong, the experiment was conducted in two universities, with 13 students in Hong Kong Polytechnic University and 5 in the Hong Kong Institute of Education. After excluding unsuitable participants, only 13 participants yielded valid data. The students were studying a variety of different majors including technology, fashion design, hotel or business management, textiles and clothing, accounting, anthropology, and surveying. Their ages ranged between 18 and 20 (freshman to junior). All had been educated in Hong Kong since kindergarten.

In Taiwan, there were nine participants. Seven came from National Chin-Yi University of Technology, two others were from Feng Chia University and National Chi Nan University, respectively. Their majors included electrical engineering, management, information engineering, and computer science. Participants' ages ranged 19-20. All had been educated in Taiwan.

From further background data which we gathered, we found that all but two of the Hong Kong students claimed to have learned Chinese characters by being taught the sound of the character as a whole. Eight, however, said this was augmented by identifying the part of the character which (usually only distantly) reflected its sound. Only one mentioned use of alphabetic transcription of the sound. With respect to unknown characters while silent reading today, seven said they would just try to access the meaning of the character as a whole without accessing its sound while ten said they would try to do it via the part of the character that would be expected to reflect the sound.

From background data, all but one Taiwanese student referred to having been first taught Chinese characters via Zhu-Yin-Fu-Hao (the Taiwanese system for phonemic transcription of the sound of Chinese characters). When asked how they now dealt with a difficult character when silent reading, however, only four of the nine said they thought about the pronunciation. The rest referred to the radical, which is the part of the character that may reflect its meaning, usually obscurely.

This information then confirms what we expected about the clear difference in initial teaching of Chinese reading to Hong Kong versus Taiwanese students. However, it hints that that clear distinction may have eroded somewhat since then. In other words, Hong Kong students at their present age seem to rely somewhat more on sound, and on breaking characters into parts, than their early predominantly whole word teaching might lead us to expect. Conversely, the Taiwan students now seem to rely a little more on treating words as wholes corresponding to meaning than their early heavily graphophonological teaching would lead us to expect.

With respect to learning English reading, again the majority of Hong Kong students (11) said they originally learned the pronunciation for words as wholes, but nine admitted to learning via letter-sound correspondences (usually along with the whole word method). When meeting an unknown English word in silent reading today, however, only seven said they would access the sound (four by a transcription of it, three as a whole word) while 11 would look at the context for the meaning (i.e. not involving sound).

For English, six Taiwanese students indicated that they first learned word reading via phonics teaching and five mentioned having first learned to read with the KK system of English phonemic symbols used in Taiwan. When meeting an unknown word in silent reading today, however, only two said they would tackle it via pronunciation. Most of the rest referred to using the context, which implies treating the word as a whole for its meaning, rather than as sounds.

Overall, then, again our expectation about participants' initial English reading teaching was largely confirmed, although there was a greater presence of phonic-type instruction reported in Hong Kong than we anticipated. In tackling words today, however, the difference between the two locations was less clear. Both seemed to have moved to a position of preferring to treat the word as a whole and focus on its meaning without regard for sound, through contextual inference.

# 3.2 Test Items

The experiment required a set of Chinese items and an equivalent set of English items. Each test had two practice sentences plus 120 test sentences that had to be responded to with 'true' or 'false'. The items were adopted from [15] and [25] and contained, in random order, 60 items where the correct response was 'true' and 60 where it was 'false'. In amongst the false items, there were targeted items where a word that made sense had been replaced either by one that was written visually quite differently but sounded similar (20 items phonologically similar to true items) or by one which had a similar spelling/character but sounded quite different (20 items graphically similar to true items). Thus for every item of interest, there were two control/distractor items.

Examples of English targeted items:

- phonologically similar (different spelling and meaning): Wear there is a will, there is a way
- graphically similar (different sound and meaning): On Saturday people do to the shops

#### 3.3 Apparatus

An eye tracker eyeNTUE-180 was used to record when and for how long the eye focused on any particular part of the screen (contact time). Each image that the students saw was divided into three regions containing three parts of the sentence, plus a fourth region that was outside the sentence. In items with graphically or phonologically confusing items, that item was always in the region labeled R1.

#### 3.4 Questionnaire

A short open questionnaire was delivered through individual interviews which elicited background information about the participants (age, major, etc.) and asked ten questions about participants' learning and practices of word reading in each language.

#### 3.5 Procedure

Following a small pilot study in Taiwan which resulted in some improvements to the items and their administration, the main experiment took place individually in a quiet room in the participant's university.

Participants were first asked to give their consent, then the researcher's assistants showed participants the notice on the screen, briefly explained the instructions and demonstrated how to use the interface. There were two practice items. The girls were asked to use hairpins to keep their fringe out of their faces. It was found that the dark frame of glasses would affect the computer location of the focal point. Therefore, students were asked not to wear glasses.

All the participants started with the English version followed by the Chinese. Each test item remained available for only ten seconds. Each test, therefore, took around 20 minutes. After they finished, participants responded to the questionnaire-interview individually.

## 3.6 Data analysis

Quantitative data were processed in SPSS. Taiwanese and Hong Kong students scored very similarly on the control/distractor items in both languages (t-tests  $p_{\dot{c}}.05$ ), which did not contain any confusing words that were either graphically or phonologically similar to the correct word for the context. That is as expected, so supports the validity of the test we used and suggests that we had not chosen samples of participants of very different proficiency or general knowledge levels in the two locations.

# 4. Results

The eye-tracking results are seen in Figure 1 and Table 1.

The eye-tracking findings show, first, that on average 41-57% of the time was spent looking at the part of the stimulus sentence that contained the word that was a source of the homonymy conflict that we had designed into the items. This part then attracted almost as much attention as both the two other parts of the sentence and the off-sentence area put together. The response of participants to spend more time fixated on the problematic part than on other parts is a natural reaction and reassures us that they were reading





Table 1. Overall comparison of the percent of contact time spent on the target between places, languages, and item types (graphic vs phonological similarity).

Source	df	F	Sig	Partial Eta Squared
Place	1	0.93	.344	.041
Language	1	2.36	.139	.097
Language * Place	1	0.26	.616	.012
Item type	1	.01	.921	.001
Item type * Place	1	.02	.890	.001
Language * Item type	1	5.74	.026	.207
Language * Item type * Place	1	0.72	.405	.032

the items properly, with attention to extracting meaning, and hence that the task was valid. A three-way ANOVA (Table 1) shows that although the Hong Kong means are descriptively a little higher than the Taiwan means, no differences involving place are significant. The only significant effect is the language by item type interaction, regardless of place. A longer time was spent focused on graphically similar items than phonologically similar ones in Chinese, but a longer time was spent focused on phonologically similar items than graphically similar ones in English. This then appears to show a form of writing system effect. Regardless of place, the writing system that lends itself to the use of the GR (Chinese) provokes more time spent on graphic similarities. This, we presume, to reflect more noticing of the conflicts, more thought about resolving them, and, it seems from Figure 2, greater consequential accuracy of response (i.e., correct rejection of the sentences given). English, where the writing system encourages more use of the PR, provokes the opposite effect. The difference in both cases is about 5% of the total contact time (Table 2). The same pattern is broadly reflected in the accuracy findings (Figure 2), where the language by item type effect is also significant (F= 10.94, p=.004, partial eta squared=.354).

# 5. Discussion

We return to the possible effects that we anticipated. With respect to the instruction effect, our background data from participants reported earlier, in fact, shows that the initial instruction received many years before by the participants in both languages was, for the most part, differentiated between places as we expected, but for a slightly greater involvement of phonic teaching in Hong Kong than we anticipated. Still, it was heavily phonic in both languages in Taiwan and predominantly whole word in Hong Kong. The effect of that on processing found in younger readers in [15] was however supported neither by the eye-tracking nor correctness findings (no significant Place by Item type effects). For example, descriptively the phonologically confusible English words proved to provoke even more eye contact in Hong Kong than in Taiwan. This is against our expectation that the greater popularity of phonic teaching of word reading in Taiwan than Hong Kong would result in more eye fixation in the former where there was a latent phonologically similar word.

The reason for this lack of clear support could be that the students are of an age too removed from initial word reading instruction at primary school level for that to have a continuing effect. Hence this supports the general view of Krashen [14] that the effects of explicit instruction are short-lived. This is supported

Language	Itom type	Meen	Std Frror	95% Confidence Interval		
	item type	Witan	Stu.EIT01	Lower Bound	Upper Bound	
Chinasa	Graph	48.33	3.975	40.087	56.573	
Chinese .	Phon	43.81	2.519	38.586	49.032	
English	Graph	49.26	3.852	41.265	57.244	
English -	Phon	54.22	3.313	47.353	61.094	





Figure 2: Responses to targeted items: correct %.

by the self-reported statements of participants about how they would handle unknown words today, where their choice was not purely reflective of the type of initial word reading instruction received in the two locations. Rather they had to some extent converged to use a more similar mix of strategies in both places and languages, approximating a balanced combination of a GR word - meaning-based approach with a PR word fragment - sound-based approach.

With respect to L1 transfer effect on the L2 word reading process, again there is no support for this from the eye-tracking (or accuracy) results. In both places, the language by item type interaction effects reflects that processing of English is significantly different from that of Chinese and does not evidence dominance of the GR as reflected in the results for Chinese. In particular, the PR is exploited far more for English than Chinese (Table 2). Thus, we instead see a writing system effect that differentiates the two languages (see below). The lack of transfer effect goes against a number of studies that have detected it such as [16] [17]. However, their designs were in many respects different, especially in that the words being decoded were not real words of the language. Hence the processing detected was not that of normal reading of familiar words.

With respect to the exposure effect, we expected students in Hong Kong, where English is traditionally a second rather than foreign language, to differ from those in Taiwan with respect to English reading. Specifically, their greater exposure and reading experience in English might mean that the former had learned to exploit the PR more for English, and generally read English more accurately than the latter. In fact, the Hong Kong students resorted to the PR nonsignificantly more than the Taiwanese (Figure 1) for English but performed notably less well in accuracy (Figure 2).

Hence there is little support for Hong Kong showing a general difference or advantage due to its greater use of English in the day-to-day life of the community. A reason for this could be that the ESL advantage of Hong Kong is becoming more and more a fact of history rather than today's reality. Since Hong Kong returned to Chinese control in 1997, the role of English has been eroded there somewhat in favour of Mandarin Chinese as the standard language of the People's Republic.

By contrast, due to competitive commercial forces, the role of English in Taiwan has been boosted and, even if it still is not widely used in daily life, its status is reflected in the importance now placed on students passing proficiency exams in English regardless of their major. Taiwan ESP (English for Specific Purposes), EIL (English as an International Language), and EMI (English Mediated Instruction) are now all strongly promoted and endorsed by the Ministry of Education. The government Executive in Taiwan has launched a 2030 national blueprint for developing bilingual education. Indeed, a 2002 national survey shows that one-third of the public kindergartens and 97% of private kindergartens already provide bilingual curriculum teaching of EIL and EFL [26].

For such reasons, the old distinction between the status of English in the two places has perhaps begun to evaporate. This is indeed supported by one Hong Kong participant who explicitly stated 'I feel my English is not good' and indeed only two of that group responded that they found it easier to read in English than in Chinese.

With respect to the writing system effect, both the eye-tracking and accuracy data support a clear significant effect of this sort. As Figures 1 and 2 show, the interpretation is supported that participants spent more time fixated on, and so presumably processing, items instantiating those conflicts that would be expected to be more noticeable when a person processes using the route favoured by the writing system: i.e., PR more than GR for English, GR more than PR for Chinese. There was, however, an unanticipated finding that greater accuracy followed longer processing time. This is intuitively quite understandable: the longer a person thinks about a homonym conflict in what they are reading the more likely they are to find the answer.

Nevertheless, the finding in some relevant past studies such as [15] and in cognitive testing in general [27] has been that slower response usually corresponds to lower accuracy. It is, however, recognised [27] that errors in the performance of cognitive tasks can arise in more than one way, involving either faster or slower times. This may be influenced by the time allowed to respond, and, associated with that, by whether conscious or only unconscious processing is involved. Kiefer and Spitzer [28] in a brain activation study confirmed that unconscious perception of words, e.g., in lexical decision tasks, involves times of only up to 200ms while conscious perception involves much longer times, albeit in similar areas of the brain. In our study, the time allowed to respond to each item was 10 seconds. Taking into account that the longest sentences used were only 13 words and that a universitylevel reader can read as much as 25 words in 10 seconds in a foreign language [29], this means that ample time was available for further processing of what was read at the conscious level to resolve those homonym conflicts that were noticed.

In the present case, therefore, we imagine a scenario on the lines that students of the level of our participants are reasonably proficient readers in the languages at issue and in fact make some use of both processing routes, GR and PR, in both languages. However, they tend to favour one or the other route due to the nature of the writing system employed in the item, i.e., graphic for Chinese and phonographic for English. As a consequence in our target items, they may access a similar word to the one they read, which makes more sense in the context, and their awareness is provoked [30]. In other words, they notice the conflict and pay conscious attention to it. As a result, after some thought, which accounts for the extra eye fixation time, they realise that the word that makes more sense is nevertheless not the one written in the test item. Hence they correctly reject the sentence as untrue. That means that if the preferred processing route is graphic, due to the item being in Chinese, then scores for the graphic similarity items are higher than those for the phonological similarity items where they may have only accessed the similar item secondarily and subconsciously without their awareness being provoked, and confusion may have occurred. By contrast in studies with more limited time allowed, expenditure of relatively longer time does not result in greater accuracy because that longer time is simply not long enough to permit the conscious processing that would achieve that outcome.

Such an interpretation would be consistent with other features of the present study, in particular the older age and greater general language proficiency of participants in this study, compared with younger learners (e.g., aged 11-12 in [15]). For instance, it is known that adult learners are more able to work at the conscious metalinguistic level than pre-adults [31]. Furthermore, at a more advanced level, we may envisage that readers both in L1 and L2 would be making effective use of dual processing. In other words, even if the writing system favours graphic processing, they still also use phonological processing, though to a lesser extent, and vice versa. For more than two decades studies have attested to dual route processing in competent readers [5]. This then explains the lower but not zero scores for the disfavoured processing route.

## 6. Implications and Conclusion

Due to difficulty in recruiting willing participants, the sample size for this study was smaller than ideal, although eye-tracking studies traditionally can involve quite small samples (e.g., 14 participants in [32]). Still, it would be a wise precaution to treat the conclusions as suggestive rather than conclusive. Having said that, it can be argued that this study potentially has interesting implications both for research and pedagogy.

For research, it suggests that eye-tracking data can show up a dimension of processing that maybe has been neglected. That is the time spent on specific parts of the stimulus sentence that is read, something which overall response latencies cannot tell us. This reveals in our case the valuable information that when the response is correct it was more rather than less time that was spent processing the key part of the sentence.

That in turn has led us to highlight the possible role of conscious processing, which again we feel has been neglected in mainline psychological research on the two routes where research designs often try to exclude it as if it is in some way undesirable. Yet in real life reading there is usually enough time for the reader to devote conscious attention to any problem that arises. Therefore, conscious problem solving needs to be researched alongside the subconscious processes rather than, as it usually is now, in a quite separate applied linguistic research tradition that only focuses on conscious processes, termed reading strategies, and does so using self-report instruments. In some ways, this is a paradoxical separation since in the psychological and educational tradition of reading research there has been a lot of work done on 'phonological awareness' and 'morphological awareness' as indicators of 'reading readiness' and wider reading abilities [33]. Yet when it comes to assessing the reading process itself the awareness dimension has often been neglected.

For pedagogy, one message of that is that awareness training has value (albeit this runs against Krashen [14], since awareness falls within the monitor which he regards as less valuable). More notably, however, the findings showed that the instructional method used for teaching initial reading, whether more graphic/lexical or phonological, does not seem to have a lasting impact on the choice of dominant processing route. Therefore, both routes are needed and whichever is highlighted in initial teaching, eventually years later proficient readers converge in all being able to operate in both routes, albeit with a preference for the route favoured by the writing system rather than the earlier teaching. Therefore, there is no benefit in the unitary positions that have been taken up in educational circles, e.g., in the UK, where one side claims that only some form of 'phonics' is the best initial teaching and the other that only 'look and say' or some extension of that such as the whole language approach is needed. Clearly, a dual approach is indicated from the start.

It does, however, emerge that the writing system has an impact on the choice of dominant route. Even within the dual teaching approach mentioned above, learners can still be prepared from the start to understand that. There is no benefit in making initial reading instruction in L1 Chinese match exactly the methods of initial reading instruction in L2 English, as has tended to happen both in Hong Kong and Taiwan. Rather, in both places, the greater emphasis in initial Chinese reading teaching needs to be on recognising the whole word and using the semantic radical, less on the phonetic part of the character and the individual sounds. For English, on the other hand, in both places the emphasis can be on highlighting phonics and KK or IPA transcription - and involve the whole word approach especially for the particular words that present few spelling clues to their sound ('exception words' like to, was, of).

Separately from reading, however, there remains a need in both places to teach Mandarin Chinese pronunciation for the many for whom that is a second language. Here resources like pinyin, or Zhu-Yin-Fu-Hao, could still be very useful.

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# The origin and evolution of Coronavirus pandemic in health science approach and Islamic perspectives

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# Abstract

In our previous articles, we have discussed the Islamic strategies for prevention and management of pandemic diseases and the preventive methods of coronavirus in Islamic perspectives and health science approaches. These two papers came first because, if one sees a snake in one room it has to killfirst before looking for the source, or if one sees a fire in his/her house the next thing to do is to put the fire off first before looking for the source. Therefore, the current paper intends to discuss the origin and evolution of the coronavirus pandemic in health science approaches and Islamic perspectives. The qualitative, library-based approach will be used as a research method and the data will be exclusively sought from the Qur'an, *Ahadith*, books, journals, and Islamic manuscripts. The findings of this study shed light that, some scientific experts traced the origin of the outbreak to a seafood market, and in one scenario, it was said the virus was through natural selection in a non-human host, the laboratory manufactured and the Muslim clerics called the virus Allah's will to punishment. The paper shows that the diseases have both positive and negative functions in Islam: as a punishment from Allah, as a means of trials and tribulations as well as a means of cleansing from sin. The paper, therefore, concludes that it remains unclear exactly how the virus originated and first spread to humans. In Islam, therefore, it happens with His knowledge and permission because with Him are the keys of the unseen treasures.

Keywords: origin, coronavirus, pandemic, Islamic perspectives, punishment

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#### 1. Introduction

Coronavirus disease has been named COVID19. It was called so because it appeared in late 2019. It was first announced in China on 4 January 2020, especially in Wuhan, that dozens of people were infected [1]. Thus, coronavirus disease spread in China and then moved to Iran through the Chinese working in the Chinese Railways Corporation to build a railway through the city of Qom. Iran is considered the epicenter of the outbreak in the Middle East. According to [2] on 4 January 2020, Italy has also opened a group of sectors for Chinese investment, from infrastructure to transportation. Reports indicate that Lombardy and Tuscany are the two regions that witnessed the largest amount of Chinese investment. The Lombardy region witnessed the first Coronavirus infection on the 21st of last February and is one of the most affected areas. It then spread to almost all the countries of the world [3]. It has led to large-scale disruptions in people's lives across the world. It is killing people of different faiths; the rich or the poor, and even doctors and nurses caring for coronavirus patients have died so far.

Schools have been closed, sports events have been cancelled and religious and cultural institutions shut down around the world as countries try to stem the outbreak. Many countries also imposed closure of the borders and curfew, and then they stopped the Friday and congregational prayers. It is also forcing people to consider the limitations of human endeavour and may lead to people being drawn back towards religion and a return to faith. This disease has given a blow to the global economy and led America to begin to exchange accusations with China [4].

[5] Added that, the pandemic has altered global human consciousness of self and others, like the one which occurred in 1918 and led to the death of millions of people all around the world. It has awakened people's consciousness to the fact that humans can only perfect the art of war against enemies they can see; there is no way one can, like Pharaoh in Ancient Egypt, predict the onslaught of the unknown or go into a war with forces, whose forte and strength are beyond the most potent nuclear arsenals the West can boast of today. If only one virus has occasioned these large-scale tragedies all around the world, imagine if ten of such were to appear in the world, the world would have imploded over the past couple of months.

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In obeisance to instructions given by governments all around the world, Muslims and Christians have consequently had to observe social physical-distancing and avoid congregating in mosques and churches on Fridays and Sundays.

## 2. The Origin and the Causes of Coronavirus

There evidences in many researches that the following may be responsible for the origin of coronavirus:

1. The outbreak was initially traced to a seafood market that sold live animals in Wuhan. Scientists have said that a type of snake may be the original source of the Wuhan coronavirus [6]. However, other infectious disease experts say the ultimate culprit is more likely to be a bat. They said further that coronaviruses are a group of viruses that can cause disease in both animals and humans. They are common in certain species of animals, such as cattle and camels. Although the transmission of coronaviruses from animals to humans is rare, this new strain likely came from bats, though one study suggests pangolins may be the origin [7].

Many reports also traced the bat origin of SARS-CoV Civets are intermediate and transmission host of SARS-CoV Epidemiological survey showed that early cases of SARS in 2002-2003 and all 4 cases in 2003-2004 had a history of animal contact through animal trade in wet markets or in restaurants where live animals were kept in Guangdong Province [8]. Molecular detection and virus isolation studies suggested that the pandemic-causing SARS-CoV originated from traded civets in wet markets. This was indirectly confirmed by the massive culling of market civets, which was believed to play a major role in efficiently containing the SARS pandemics and no further SARS case was reported after 2004 [9]. However, subsequent extensive epidemiology studies did not find SARS-CoV in farmed or wild-caught civets, indicating that another animal(s) was involved in SARSCoV transmission in the animal market or other trading activities and civets are unlikely the natural reservoir of SARS-CoV [10]. Regarding the discovery of diverse SARS-like coronaviruses in bats Several years before the outbreak of SARS, two other zoonotic viruses, Nipah virus and Hendra virus, emerged in Asia and Australia and they were both known to be originated from bats. These led scientists to consider bats in the search of reservoirs of SARS-CoV.

In 2005, a breakthrough was made as two independent research groups reported, almost simultaneously, the discovery of novel coronaviruses related to SARS-CoV in horseshoe bats (in the genus Rhinolophus) in China, which were termed SARS-like coronavirus (SL-CoV) [11]. These bats SL-CoVs from both mainland China and Hong Kong manifested genome sequence identity of 88-90% among themselves and 87-92% identity to human or civet SARS- CoV isolates [12]. The unique set of ORFs exclusively found in SARS-CoV was also present in bat SL-CoVs, demonstrating the close phylogenetic relationship between SARS-CoV and SL-CoV. The discovery of bat SL-CoV boosted researchers' interest in coronavirus surveillance studies in bats [13]. In the following years, SL-CoV RNA was detected in Rhinolophus species of a wider geographic range in China. The provinces or regions where SL-CoV-positive bats were captured included Hong Kong, Guangxi, Hubei, Shandong, Guizhou, Shaanxi, and Yunnan [14].

2. In one scenario, the virus evolved to its current pathogenic state through natural selection in a nonhuman host and then jumped to humans. This is how previous coronavirus outbreaks have emerged, with humans contracting the virus after direct exposure to civets (SARS) and camels (MERS). The researchers proposed bats as the most likely reservoir for SARS-CoV-2 as it is very similar to a bat coronavirus. There are no documented cases of direct bat-human transmission, however, suggesting that an intermediate host was likely involved between bats and humans [15].

In this scenario, both of the distinctive features of SARS-CoV-2's spike protein—the RBD portion that binds to cells and the cleavage site that opens the virus up would have evolved to their current state prior to entering humans. In this case, the current epidemic would probably have emerged rapidly as soon as humans were infected, as the virus would have already evolved the features that make it pathogenic and able to spread between people [16].

3. America attacked China for its failure to fight the epidemic and for concealing it since its inception. So, Chinese Foreign Ministry spokesman, Zhao Li Jian, responded angrily and wrote on his Twitter account on 13/3/2020, saying according to [17] report on 13/03/2020, "The American army may have brought the Coronavirus to the Chinese city of Wuhan ... " On 19/3/2020, Euro News [18] reported that US President Trump repeated his attack on China, saying: "The world is paying a very big price for what they did (referring to China's slow pace in providing information about the new Coronavirus)". Trump described the Coronavirus as the Chinese virus when he posted a tweet on 16/3/2020 on Twitter: "The United States will be powerfully supporting those industries, like airlines and others, that are particularly affected by the Chinese Virus. According to the report of [19] on 18/3/2020, China responded through its Foreign Ministry spokesman on 17/3/2020 and said: "This comment distorts the image of China. We are very angry and we strongly reject it". And when China began spreading accusations that initially mentioned that America was behind the spread of the virus, Washington summoned its Beijing ambassador on 13/3/2020 and a State Department official said: "China is seeking to deflect criticism for its role in 'starting a global pandemic and not telling the world.' Spreading conspiracy theories is dangerous and ridiculous." On 15/3/2020, the official said, "We wanted to put the government on notice we won't tolerate it for the good of the Chinese people and the world." Xinhua agency confirmed "that Beijing's actions, including imposing strict quarantine on millions of people, have given the world "valuable time" to prepare, which is recognized by the international community." [19][20]

Thus, a war of words broke out between America and China because of the outbreak of the Covid19 virus (SARS-CoV2), and both countries accuse each other of being the direct factor in the spread of this disease, and although both systems applied in China and the United States are not excluded from being behind the spread of the virus, however, after research, it is likely that there is no concrete evidence that neither the United States nor China was the one that transmitted or manufactured the virus and then proceeded to transmit it to other countries for two distinct reasons:

The first is that both countries are drowning to their ears in this disease!. In China, in addition, the last statistic of coronavirus disease according to [21] on 23/3/2020, the number of the affected reached 81,272, and the number of deceased is 3,273 as stated in the announcement of the National Health Committee in China. Even if it were China who was behind the spread of the disease, it would have at least protected itself. As for America, according to the statistics of those affected by the Coronavirus disease according to [22] on 25/3/2020, the number of deaths from the virus has increased to 704, while the total confirmed cases reached 52,976. The United States ranks third in terms of the number of infections by the virus after China and Italy. [23] also reported on 23/3/2020 that, under the recent measures, a third of Americans are subject to orders to stay at home in seven states, as the states of Louisiana and Ohio announced on Sunday an expanded curfew, thereby joining the states of New York, California, Illinois, Connecticut, and New Jersey. And likewise, if it were America who was behind the spread of the disease, it would have at least protected itself from it [24] [25].

The second is that it is incorrect to say that either country manufactured it because there is no evidence that the virus was manufactured in the laboratory. Now, by comparing the genome sequencing data available for known coronavirus strains, one can strongly confirm Coronavirus has originated through natural processes. This view was supported by data on the virus's backbone and its overall molecular structure, and whoever wanted to manufacture the virus in vitro, this would show in the backbone of the virus" [24] [25]. The same applies to any other country such as Russia, Europe, Iran, and other Muslim countries, as it is likely affected by one of the two countries, China, and America, in terms of transmission of the disease.

4. On hearing initial reports of the deadly spread

of coronavirus in China, many in the Arab world rejoiced. Arab social media threads called the virus Allah's will to punish the Chinese for their cruel treatment of the Uighur Muslims of western China [26]. When the virus broke through China's borders and landed in Iran, the Arab world was even happier. Images of Iran's suffering as a result of coronavirus, and discussion of its rapid spread throughout the country, went viral on social media. Again, many Arabs claimed this was Allah's wrath, this time over Iran's heinous treatment of Sunni Muslims in Iraq, Yemen, and Syria. When the coronavirus first began infiltrating the wider Middle East after its initial outbreak in Iran, many in the Arab world thought it might be an Iranian conspiracy [27].

For instance, in an unusual sermon, Jordanian MP, a former minister and a lecturer at the University of Amman Muhammad Abdulhamid Qudah, called the coronavirus a "soldier of Allah" and said it had been sent to punish both the West and Muslims. He claimed Allah is angry with the world, especially Muslims, because they have failed to obey him [28]. Also, Bashir bin Hassan, a controversial Salafist cleric in Tunisia, posted on his Facebook account, which has over 500,000 followers, that the Chinese are being punished by Allah because of the siege they have set against the Uighur Muslims. According to the cleric, Allah has many soldiers, including both angels and viruses. He added that just as Allah drowned Pharaoh's soldiers in the sea, he is similarly granting victory to the Uighurs [6].

Again, the Kuwaiti cleric Uthman Khamis stated in a sermon on his YouTube channel that, this is not the first time Allah has visited his wrath upon the world: he also sent a mosquito to kill Nimrod and unleashed the ten plagues to punish the Egyptians. The coronavirus is, thus, another warning to humanity from Allah. The only solution is to return to him and follow his ways; only then will the virus disappear [29].

There is no doubt that coronavirus is a matter of serious concern not just to the West, but to the Arab world as well. As Arab populations succumbed to widespread panic and fear the governments throughout the region scrambling to contain the virus, closed mosques and shut down most activities of the society. Even Islam's holy cities of Mecca and Medina closed their sacred sites, public prayer has ceased in those cities. The International Union for Muslim Scholars (IUM) released a religious edict forbidding Muslims from praying at mosques and calling on them to protect themselves from infection. The IUM urged Muslims to pray at home and stay away from holy sites [29][30].

Yet, to some Muslims, the avoidance of mosques in times like this and the imposition of restriction of movement or complete lockdowns on cities enjoy credence in Islamic jurisprudence, compliance with government's instructions by the Muslim has been read by some critics to mean the acceptance of "a breach in what is considered sacred... (that) humans are now forced to accept that self-preservation is higher than the worship of God and (that) the state is superior to any deity" [31].

# **3.** Islamic Perspectives on the Origin of Coronavirus Pandemic:

According to Islam, everything that happens is from Allah and only from Him. Human beings, whilst having the willpower to do things, have no power to change the outcome or the end result. It is mentioned in the Glorious Qur'an, 9:11: "Nothing shall ever happen to us except what Allah has ordained for us." The Prophet expressed this very same verse in the following manner: "Whatever has befallen you was not meant to escape you, and whatever has escaped you was not meant to befall you" [32]. No one will completely feel at ease until he/she firmly believes that Allah has already preordained all matters. Therefore, in Islam, it is true that the virus is a creation of Allah. It happens with His knowledge and permission as the Qur'an, 6:59 says: And with Him are the keys of the unseen treasures none knows them but He; and He knows what is in the land and the sea, and there falls not a leaf but He knows it, nor a grain in the darkness of the earth, nor anything green nor dry but (it is all) in a clear book. Allah is in full control of the universe and fully aware of all events nothing happens in this world except through the leave of Allah. Therefore, a person who has been suffering from distress should know that Allah is fully aware of all that has happened or been happening to him.

The believer should also know that Allah is aware of every little detail of everything that happens, so much so that not even a leaf falls from a tree without Allah being aware of it: He knoweth whatever there is on the earth and in the sea. Not a leaf doth fall but with His knowledge: there is not a grain in the darkness (or depths) of the earth nor anything fresh or dry (green or withered) but is (inscribed) in a Record Clear (to those who can read). (Qur'an, 6:59) No misfortune can happen on earth or in your souls but is recorded in a decree before We bring it into existence: that is truly easy for Allah: in order that ye may not despair over matters that pass you by ... (Qur'an, 57:22-23). Therefore, the believer should take relief and comfort from the fact that Allah is fully and intimately aware of his situations. Any harm or injustice that he has been subjected to by anyone, will not go without a consequence. Or if he is suffering from distress and difficulties, then his suffering is constantly being watched by Allah.

Hence, the coronavirus pandemic which is today creating havoc to the entire human race, irrespective of colour, culture, religion, nationality or status does not come as a surprise in Islam, because the Holy Prophet of Islam has warned people over one thousand five hundred years ago saying: If unlawful *fahishah* (bad deeds or speech) become common in any group or nation, Allah will punish them with epidemics and diseases which were not known to their forefathers and earlier generations [33]. One of such diseases is a coronavirus which can be contacted through different sources as highlighted above. The above *Hadith* shows that the coronavirus pandemic was not in existence in the olden days. It came into being as a result of human engagement in unlawful acts.

Also, at a superficial glance, this *hadith* seems to almost perfectly predict any pandemic; for this reason, the *hadith* has been used by a number of Muslim writers to argue that coronavirus is a curse from Allah [34]. This is, however, only part of a larger *hadith*. 'Abd Allah bin 'Umar said: The Messenger of Allah (SAW) came to us saying, 'O Muhajirun (the exiles from Mecca)! There are five things when you are tested by them, and I seek refuge by Allah that you should experience them.

1. Whenever *fahishah* have appeared amongst any nation, which the people of that nation commit openly, an epidemic or diseases that they have never encountered before became widespread amongst them.

2. Cheating in weighing (dishonest behaviour in any money transactions) will result in a crisis of poverty and tyranny.

3. Unwillingness to pay *Zakat* (alms) will result in an extended dry season, without rain so much so that if it were not for cattle, it would not rain at all.

4. Damaging the bond between Allah and the Prophet Muhammad (SAW) will result in the appearance of an enemy.

5. Leaders refusing to base laws on the revelations of Allah will cause enemies within their own ranks [33][35].

Therefore, the coronavirus pandemic has become one of such diseases and abominations.

Hence, some Islamic scholars argued that, if one understands *fahishah* to mean disobedience of Allah, and argues that this is the cause of coronavirus pandemic, why have the pandemic hit those parts of the world where the laws of Allah are often followed. Therefore, pandemic, epidemic, illness, and disease seem to have both positive and negative functions in Islam.

# A. As a Punishment from Allah

All participants were studying at the tertiary level, through the medium of Chinese. They were volunteers paid to participate in this experiment. In Hong Kong, the experiment was conducted in two universities, with 13 students in Hong Kong Polytechnic University and 5 in the Hong Kong InsOne challenge in responding to coronavirus pandemic from an Islamic perspective is the belief of some Muslims that sickness and disease are a curse from Allah. The belief that disease and sickness are a curse from Allah can be understood to arise from specific interpretations of a number of verses from the Qur'an. Interpretation of the Qur'an is indeed a difficult task due to the highly specific and nuanced character of Arabic language. Thus, different interpretations of Qur'anic verses can arise due to different translations or understandings of specific words. For instance, the two versions of the same verse below (Qur'an, 30:41) use different English words in translation from Arabic. The consequence of this is to give two different interpretations of the same verse: "Corruption has appeared in the land and the sea on account of what the hands of men have wrought...." (Qur'an, 30:41) "Evil has spread in the land and on the sea because of what humankind has done." (Qur'an, 30:41)

In a similar way, different Qur'anic verses can use different words to describe sickness. For example, in Qur'an Chapter, 21 verse 83, the Prophet Ayub prayed 'innimassanniya al-dhurr' which translates to 'true distress has seized me.' However in Qur'an Chapter, 38 verse 41, Al-Anbiya is quoted as stating "inni massaniyaal-syaithan bi nushb wa adzab, which translates as 'the evil one has afflicted me with stress and suffering.' Thus the use of different key terms to describe illness can lead to different interpretations of the Our'an, and in this way, some Muslims view illness as merely being seized by distress, while others view sickness as being influenced by Satan. However, when understood in the context of the Qur'an in full with references to other verses, it can be argued that Islam does not, in fact, promote a view of illnesses like coronavirus pandemic as a curse of Allah or punishment for wrongdoing. For example, prophets are surely dearest to Allah, and yet the Prophet Ayub suffered from serious sickness for many years, and the Prophet Muhammad (SAW) himself also suffered from illnesses. Indeed all human beings at one time or another face illness. Furthermore, in the Qur'an it is stated 'Wa ma yazhlimu rabbuka ahadan', which translates as 'your Allah will not be cruel to anyone'. While there may be instances where disease can be spread as a result of deviating from the way of life prescribed by the Qur'an and prophetic traditions as in the case of coronavirus pandemic, it remains the duty of Muslims to respond in a compassionate way to those affected.

For example, when some of the people of Egypt mocked Prophet Musa, they told him: "Whatever be the signs that you bring to us to work your witchcraft, we shall never believe in you". And then Allah, the Qur'an says, "sent (plagues) on them: wholesale death, locusts, lice, frogs, and blood signs openly self-explained: but they were steeped in arrogance, (and were) a people given to sin" (Qur'an, 7:134). Hadrat 'A'ishah asked the Prophet of Allah about the plague and he replied, "That was a means of punishment which Allah used to send upon whomsoever He wished" [36].

In another Hadith, he said: Narrated 'Aisha: (the

wife of the Prophet) that she asked Allah's Apostle about plague, and Allah's Apostle informed her saying, "plague was a punishment which Allah used to send on whom He wished, but Allah made it a blessing for the believers. None (among the believers) remains patient in a land in which plague has broken out and considers that nothing will befall him except what Allah has ordained for him, but that Allah will grant him a reward similar to that of a martyr" [36] [37]. In another event, a prostitute ... was forgiven because of a dog she passed at a well, panting through intense thirst that was almost killing it. She took off her (leather) sock, tied it to her scarf, and drew some water for it. She was forgiven her sins (for doing that) [33] [35] [38].

Is it possible that a cure has not been found for coronavirus pandemic at the stage precisely because they are a punishment from Allah or a warning to people about their disobedience to the will of Allah?

i. If this is the case, how do we explain that there is no cure for cancer? Also, would it not be going against the will of Allah to seek a cure for coronavirus epidemic?

ii. How does the ability of wealthy nations or individuals to afford treatment for a particular disease?

iii. In the case of coronavirus epidemic, to fund treatment for others-does it fit in with the idea that coronavirus epidemic is a punishment from Allah?

iv. Can this *hadith* be used to make excuses for commercial sex work today, or can it be used to show that everyone can receive Allah's mercy?

Therefore, if Allah was to punish men according to what they deserve He would not leave on the back of the (earth) a single living creature: but He gives them respite for a stated Term: when their Term expires verily Allah has in His sight all His servants.

#### B. As a Mean of Trials and Tribulations

The Coronavirus may be a result of trials and tribulations because, according to Islam, the life of this short and transitory world is but a test and a trial from the Lord... the real place to receive rewards and punishments is only the Hereafter. Therefore, in Islam all diseases such as the coronavirus (Covid-19) are tests from Allah and a natural part of life. Such diseases afflict whomever Allah allows them to afflict and they take the lives of whomever He has decided to bring to an end. Tests are natural, albeit difficult, part of life, and should not be surprising for any Muslim when they occur. Allah says, "We shall certainly test you with fear and hunger, and loss of property, lives, and crops. But (Prophet), give good news to those who are steadfast" (Qur'an 2:155). Anyone who is afflicted with the illness, and is patient, will spiritually benefit from that test. The Prophet said, "Whatever trouble, illness, anxiety, grief, hurt, or sorrow afflicts any Muslim, even the prick of a thorn, Allah removes some of his sins by it" [36] [37]. Regarding illnesses leading to death, the Prophet was asked about the plague. He responded, "It is a torment with which Allah afflicts those whom He chooses, but He has made it mercy for the believers. If a servant (of Allah) is afflicted with the plague and patiently remains in his town, realizing that he has only been afflicted with what Allah has determined for him, he will have the reward of a martyr" [34] [36] [39].

When an individual sits down and reflects upon his difficulties and makes an objective analysis of the events and actions leading to his situations, he will almost always identify some things he did that he should not have done or he did not that he should have done, which led to that situation. For example, for parents who suffer from their rebellious and disobedient teenaged child, it will be found, almost without exception, that they did not arrange his proper Islamic education and a good environment, and did not give it enough priority to engage themselves with his upbringing. Indifference or inaction can be as serious as committing a sin or making a bad decision, which can lead to grave consequences.

Though calamities may hit a believer as a surprise, the reality is that by virtue of being a believer one is supposed to suffer. If a believer understands the Islamic philosophy that this life is a testing ground, then he should realize that this philosophy will be implemented for him in practice while he lives in this testing ground, and not after he dies. Tests are not just limited to seeing whether one performs the rituals or not. His belief and commitments to Allah, and his focus in the Hereafter will be fully and thoroughly tested with calamities and afflictions to gauge the depth of his faith in his heart. Achieving Paradise will not be easy. It will come only with unshakable faith and trust in Allah. Allah, says: Ye shall certainly be tried and tested in your possessions and in your personal selves (Qur'an, 3:186). Do men think that they will be left alone on saying "We believe" and that they will not be tested? (Qur'an, 29:2) Be sure We shall test you with something of fear and hunger, some loss in goods or lives or the fruits (of your toil); but give glad tidings to those who patiently persevere (Qur'an, 2:155).

One individual once told another one who was going through tribulations that Allah was displeased with him, and hence his difficulties. This man lacked wisdom, for his comment was offensive to the person who was already distressed. More importantly, his understanding was incorrect from an Islamic perspective. The one who received the comment was a gentleman and also knowledgeable in Islam. Thus, it was not surprising that he decided to digest his remark and refrained from giving a response. There are people who do maintain that incorrect understanding. Whenever they see a believer who is suffering from some calamity or disease, they think that this is a reflection of Allah's wrath on him. They should remember about the Companions of the Prophet who were severely persecuted or even killed after becoming Muslim, an event that wipes out all past sins. Even the prophets of Allah, who ever walked on the face of the earth, were persecuted by their community without exception. Was Joseph not thrown into a well, sold as a slave, and then thrown back into prison? Did Job not face the severest of trials one after another, and was eventually left out by all except his wife? In fact, the Qur'an tells us that many prophets were brutally killed by unbelievers. These examples should establish the fact that trials and tribulations are not a sign of Allah's displeasure on someone. Quite the contrary, it is rather a sign of Allah's love on someone. The Prophet said: When Allah who is Great and Glorious loves people He afflicts them [with trials] [36] [37] [39] [40].

The punishment in the Hereafter is much severe in fact unimaginable from our worldly perspective than any affliction one can face in this world. Therefore, when Allah loves someone and intends for him or her to go to Paradise, He wipes out his sins and mistakes and rewards him highly by putting him to afflictions in this world.

The stronger the faith, the harder the test, and the greater the reward a believer afflicted with a severe calamity should take comfort from the fact that those who have strong faith are given the harder trials. This is established by the Prophet. When asked about who suffers the greatest afflictions, he replied: The prophets, then those who come next to them, then those who come next to them. A man is afflicted in keeping his religion. If he is firm in his religion his trial is severe, but if there is weakness in his religion it is made light for him, and it continues like that till he walks on the earth having no sin [33] [35] [38] [41]. Why is it, one may ask, that people who are faithful and righteous should have to suffer? To get an answer, we should ask ourselves: is there any achievement without an effort or any fruit without labor? The obvious pattern that we see in our human experience is that those who work hard and go through the process of struggle are rewarded with success in this materialistic world. The greatest reward of everything that one can imagine is Paradise. In fact, the bliss and happiness in Paradise is so great that one cannot even imagine it (Qur'an, 32:17).

How can then one expect that he will achieve this greatest success without him being thoroughly tested to see if he qualifies for it? One should not think that following the rituals, such as making salat five times a day, is enough test for him. The external rituals that we do and the laws of the shari'a that we observe returns immediate benefit to us as they bring peace and happiness to our families and provide us with a healthy social and moral society in which to live and prosper.

Thus, one should not expect that observing Allah's commandments and reaping these benefits in turn is the only test. The real test is the test of the heart where faith lives, and that is tested with affliction and hardship to check if the faith and trust in Allah is firm and well-rooted or is it weak and superficial: Do men think that they will be left alone on saying "We believe" and that they will not be tested? We did test those before them and Allah will certainly know those who are true from those who are false. (Qur'an, 29:2-3) Each believer, therefore, must expect to be tested. The stronger his faith, the harder will be the test, and the greater his reward will be if he remains patient having unshakable faith and trust in Allah. The Prophet said: "The magnitude of the reward is proportionate to the severity of the trial. When Allah loves a people, He tests them. Whoever accepts that shall be pleased, but whoever is discontent shall be devastated" [42]. And the believers will continue to go through trials and tribulations in their life until their sins are wiped and they die and meet Allah free from all sins. Never is a believer afflicted with discomfort, illness, anxiety, grief, or mental anguish, or even something as trivial as the pricking of a thorn, except that Allah will expiate his sins on account of his patience" [43]. That is so because Allah, in His mercy and generosity, not only rewards one when he is patient through his trials, but also sheds his sins for the pains and sufferings that he or she goes through. No matter how small the trial or how insignificant the discomfort, Allah will reward him for that and eliminate some sins.

Islam requires believers to put their trust in Allah and utilize the means to protect themselves when possible. The Qur'an teaches, as told to the Prophet, "Say: Nothing will afflict us except what Allah has decided for us." (Qur'an 9:51). Finally, Abu Hurairah narrates that the Prophet said: "When Allah wants to be good to someone, He tries him with some hardship" [44].

#### C. As a Mean of Cleansing from Sin

The coronavirus may also be a result of cleansing from sin. This is because according to Islam, the blessings of those who fall sick is that sickness is one of the strongest and most powerful antidotes to the sins that commit. There is hardly anything that will expiate sins that is more powerful than trials and afflictions that befall us. Allah says: "And whatever strikes you of disaster it is for what your hands have earned; but He pardons much (Qur'an 42:30)". Every sickness and calamity that happens: a death of a loved one, a loss of a relative, financial economic, distress physical hardship, a fever, any type of pain and suffering. For instance, once the Prophet Muhammad (SAW) visited a sick person who was suffering from fever, he said: "I have good news for you. For verily My Lord has told me that fever is my punishment that I inflict upon my believers so that they don't have to be punished in the hell." This is a punishment that Allah inflicts so that you are saved from the punishment of the next life. so in fact, it is a blessing in disguise [36] [39] [45]. And once the Prophet Muhammad (SAW) visited a female companion, Umm Sa'ib. She was also suffering from fever; she was tossing and turning. When Prophet Muhammad asked her: What is the matter? She said: "I have a severe fever may Allah curse it!" The Prophet said: "Do not curse the fever, for verily it forgives sins like a furnace gets rid of the impurities in iron" [46]. When you put iron into the furnace, it is full of impurities; when you take it out, it is 100% pure. So, the Prophet compared the fever to a furnace, and this is a very good comparison because both are burning. And in another hadith he said: "It will get rid of your sins like a tree in the fall. When you shake it all, the leaves come down. So too will the sickness get rid of your sins." Every calamity is for your good. This is something that applies to every single calamity and misfortune. So much so, the Prophet said: "Even if a thorn pricks one of you, it will expiate some of your sins" [36] [39] [45] [47]. In another hadith, it was reported that, Hadrat A'ishah (R.A) reported that the Prophet said, "When a believer suffers from illness, Allah purifies him just as the impurities of iron are cleansed in a furnace" [46] [48]. The Prophet was also quoted as saying, "If a Muslim is afflicted in his (or her) body, what he (or she) did when he (or she) was in good health will be recorded for him (or her) as long as he (or she) is ill. If Allah restores his (or her) health and cleanses him (or her from sin), and if Allah causes the person to die, he (or she) will be forgiven." In yet another hadith, narrated in the Muwatta of Imam Malik, we learn of the Prophet's response to one person who had died. A man said, "He was fortunate," as he had died without being tried by illness. The Messenger of Allah also said, "Alas for you, if you only knew that if Allah had tried him with illness, He would have wiped out his wrong actions" [46] [48] [49].

Also, Abu Hurairah reports that Allah's Messenger said: "For every misfortune, illness, anxiety, grief, or hurt that afflicts a Muslim -even the hurt caused by the pricking of a thorn Allah removes some of his sins". In another *hadith*, it was reported that, Ibn Mas'ud said: "I visited the Messenger of Allah while he had a fever. I exclaimed: "O Messenger of Allah! You have a high fever!" He said: "My fever is as much as two among you (might have)." I asked: "Is it because you have a double reward?" He replied: "Yes, that is right. No Muslim is afflicted with any hurt, even if it is no more than the pricking of a thorn, but Allah wipes off his sins because of it and his sins fall away from him as leaves fall from a tree" [46] [48] [49] [50].

Also, narrated by Abu Said Al-Khudri and Abu Huraira that the prophet said: "No fatigue, no disease, no sorrow, no sadness, no hurt, no distress befalls a Muslim, even if it were the prick he receives from a thorn, but that Allah expiates some of his sins for that" [46] [48] [49] [50] [51]. Therefore, in Islam, fever, illness, sickness, diseases, or any calamity or hardship that befalls a believer may not be only punishment from Allah but rather it may be a trial and a mercy from Allah, for through these afflictions Allah explates some of the sins of that person.

#### 4. Conclusion

This paper has examined the origin and the causes of coronavirus pandemic by the scientific experts, the America/China belief, the Muslims and Islamic perspectives. The findings of the study shed some light that, there are many theories about the origin and sources for the coronavirus outbreak in Wuhan, China. Some scientific experts traced the origin of the outbreak to a seafood market, and in one scenario, it was said the virus was through natural selection in a nonhuman host, the laboratory manufacture and it was called the virus Allah's will to punishment. The paper also showed that the disease seems to have both positive and negative functions in Islam: as a punishment from Allah, as a means of trials and tribulations and as a mean of cleansing from Sin. It recommended that Muslims should be very careful not to jump to premature conclusions. It concluded that it remains unclear exactly how the virus originated and first spread to humans. In Islam therefore, it happens with His knowledge and permission. And with Him are the keys of the unseen treasures and He knows what is in the land and the sea, and there falls not a leaf but He knows it, nor a grain in the darkness of the earth, nor anything green nor dry but (it is all) in a clear book.

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# Politics of reconciliation and new local governance based on Sufficiency Economy Philosophy and the King Rama IX's Working Philosophy: Case studies of local administrative organizations in the eastern region of Thailand

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# Abstract

The objectives of this research are to study the driving of local administrative organizations (LAO) in accordance with the Sufficiency Economy Philosophy (SEP), measure the level of SEP practices, and propose an appropriate model of reconciliation politics and local governance for the LAOs in the eastern region of Thailand. The research utilizes the integrated methodologies of case study, mixed-method, and lesson-learned method. The research results show that none of the 15 LAOs in this research fit in the very high level of SEP principles—or becoming a healthy workplace for all; nine of them occupy a high degree of SEP practices—or a level of understanding and being happy workplaces; four of them are at a moderate degree-or a level of being within the scope of the SEP and being sustainable workplaces; and, finally, the last two are not fit in the scope of SEP practices. Additionally, the research proposes five models for the LAOs' political driving.

Keywords: new local governance, Sufficiency Economy Philosophy, King Rama IX's Working Philosophy

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# 1. Introduction

From the historical analysis of the local government in Thailand, it is found that the current local government direction is in a state that does not follow the desirable model of development. This is because there is still a process of struggle between the groups that support decentralization under the policy framework of the constitution B.E. 2543-that based on old localism-and the groups that support the centralization of power after the coup in 2014, led by the government of the National Council for Peace and Order. This research project is an attempt to propose a third option, that is, to apply the Sufficiency Economy Philosophy (SEP) of King Bhumibol Adulyadej in Thai politics and local government. The late king presents the important principles of morality and ethics in governing the country, such as the principle of unity, rule of law, citizenship building through education, etc. Therefore, this study will apply the moral and ethical principles for governing proposed by King Bhumibol Adulyadej. This will be made as the ethical base of contemporary decentralization theories in international academic circles, especially the new localism theory. This is because the new localism has

many fundamental principles consistent with the SEP and Working Philosophy of King Bhumibol Adulyadej the Great Borommanatbophit, for example, the concept of local public value management of new localism and the working principle for common interest, the concept of self-management community with the working principle of self-supporting, and the concept of networked community governance with the working principle of 'know how to treasure unity' (*'ru rak samakki'* – in Thai), etc. [1]

# 2. Objectives

1. To study the operations of local administrative organizations (LAO) in the eastern region according to and fitting in the scope of the SEP principles and the King Rama IX's Working Philosophy.

2. To study the models for driving the LAOs' politics of reconciliation based on the SEP and the King Rama IX's Working Philosophy in the area of the eastern region.

3. To study appropriate models for driving the new local governance of the LAOs based on the SEP and the King Rama IX's Working Philosophy in the eastern region.

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The Research has been carried out by utilizing the three integrated research methodologies as follows: case study, mixed methods research in the combination of quantitative and qualitative research and lesson-learned methodology.

# 3. Theoretical Framework for the Study

This study uses the concepts of SEP, the philosophy King Rama IX's Working Philosophy, new localism, local governance, politics of reconciliation, community engagement, social capital, and networking. The theoretical framework for this study can be shown as follows: The research conceptual framework in Figure 1 is a hypothetical model, which was used as a working hypothesis and a tool for helping data collection and analysis as well as a guideline to search for an appropriate model in the conclusion of the final research. Since this research project is based on a qualitative research approach using inductive process research, it is, therefore, important to present the results from concrete to abstract conclusions [4].

In applying to politics and local governance, the SEP and the King Rama IX's Working Philosophy are considered as connecting mediators of the local government process. According to Chaiyon Praditsil, et al., [1] the factors of the SEP and the King Rama IX's Working Philosophy have effects on the politics of reconciliation and the new local governance of multisectoral networks' collaborations. As a result of these connecting factors, a working hypothesis for this research can be presented as follows:

1. Driving towards the politics of reconciliations of the LAOs in the eastern region. This driving is the results of basic factors of honest and sincere political leaders, mechanisms and processes of community engagement in the political decision making as well as social capital in the communities. Additionally, supporting factors are the result of the historical context of each community and the different background of each LAO. These factors have led the LAOs in the eastern region to operate in accordance with the model of honesty and sincerity, harmony (*'rurak samukki'* in Thai), common benefit focus, community participation, selfreliance, etc.

2. Driving towards new local governance of the LAOs in the eastern region. This driving is the result of the basic factors of the public-minded leaders' networks, learning process of the people, and collaborative networks between the LAOs and the people organizations in the communities. In addition, there are additional factors resulting from the historical context of the community and the background of each LAO that are different from place to place. These factors have led the LAOs in the eastern region to operate by using the King Rama IX's Working Philosophy approach, namely honesty and sincerity, perseverance, simplificity, patience, hard working, know how to trea-

sure unity ('*rurak samukki*' in Thai), common interest, people participation, topographical and sociological approach, etc.

This research aimed to measure level of sufficiency economy by indicators of three level SEP as Figure 2.

#### 4. Research results

First of all, the results of the first research objective– the level of SEP of the 15 LAOs in the eastern region – are summarized in Table 1 as follows:

Table 1 shows the result of quantitative study for measuring the levels of the SEP practice of the 15 LAOs in this study. Four levels of the SEP are divided: firstly, 'not qualified' if scores do not fall into the qualified level; secondly, 'qualified' if scores reach the level of sustainable workplaces; thirdly, 'understanding' if scores fit in the scope of a happy workplace; and finally, 'achieving' if scores reach a level of being within the scope of a healthy workplace of all. The study reveals that none of the 15 LAOs in the research fit in the very high level of achieving the SEP principles-or becoming a healthy workplace for all. Nine LAOs are at the understanding level, namely Klong Plu Subdistrict Municipality, Bang Sa Kao SAO, Khlong Hinpoon SAO, Ban Song District Municipality, Takad Ngao SAO, Koh Wai SAO, Ban Phra SAO, Bang Klua SAO, and Chanthaburi PAO. Two of them-Samaesarn SAO and Koh Mak SAO-do not qualify for their operations in accordance with the SEP principles because they have the problems of internal administration-namely a lack of transparency, unhealthy governance, and law infringement.

Regarding the qualitative study, five LAOs have spent budgets for projects and activities with wrong purposes. These LAOs have used a large amount of money for annual wages and other unnecessary expenditures, and only a little money left for spending on useful community development as it should be. In addition, some LAOs have not tried to solve a problem of community members' misconduct or bad behavior (*'abaiyamuk'* in Thai) related to their everyday lives.

There are four LAOs that have followed the principles of SEP, namely Huai Raeng SAO, Noen Kho Subdistrict Municipality, Koh Chang Tai Subdistrict Municipality, and Bo Phloi Subdistrict Municipality. The fact that all of these four LAOs can overcome the qualifying score—especially their characteristics of transparent management, good governance, and no violation of law—and attain the understanding level as can be seen from their participatory planning and operations, as well as succession planning. However, all of the four LAOs remain unable to create a happy workplace because of their internal problems, such as the lack of public minds of personnel in helping colleagues' works and creating an unhappy atmosphere

#### **Research Conception Framework**



Figure 1: Framework for the application of SEP and the King Rama IX's Working Philosophy to new local governance [2] [3].

in their workplaces like the second home. This is because of their staffs' lack of sympathetic joy (*'muttita chit'* in Thai) and equanimity (*'xubekkha'* in Thai), especially, during the time of annual raise, their rivalry against each other, disunity, lack of working as a team, etc.

Moreover, from the qualitative study, two LAOs do not fall into the qualifying level of the SEP category, namely the Samae San SAO and the Koh Mak SAO, due to the absence of transparent administration, good governance, and infringement of law. They also lack of succession planning. The study shows very serious difficulties of one SAO as the president faced many problems of being prosecuted under Section 157 of the Criminal Code for his malpractice in helping his family's illegal fishing against the Royal Ordinance on Fisheries B.E. 2558 (2015). In addition, some LAOs had no president, leaving responsibility for overseeing the LAOs' work in the hands of local government officials. Furthermore, because of the local government officials' rivalry against each other, some face the problem of being prosecuted unavoidably. The problem of unreadiness of the president in these SAOs also

has an impact on their succession plan.

For responding to the second objective, the research reveals that the model of local politics of reconciliation is generally based on community culture, which can be extracted from the lessons learned in Noen Kho Subdistrict Municipality, Bang Sa Kao SAO, Koh Chang Tai Municipality, and Bang Kluea SAO. This model is a driving process that constitutes either reconciliation politics through informal or personal consultation between their elected executive leaders and the management in the new line of local governance, which links the LAOs to their communities. The factor of community culture is an important foundation, which includes the way of life, system of thinking, value, and ideology of each community. These cultures have been established in the past, inherited from one generation to the next generation, and maintained to the present. In driving the local governing model, such reconciliation should apply the three principles of King Rama IX's Working Philosophy-topographical and sociological approach, honesty and sincerity, and know how to treasure unity ('ru ruk samukki' in Thai).

For responding to the third objective, this research

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		Onimate outcome
Qualifying	Understanding	Achieving
(Sustainable Workplace)	(Happy Workplace)	(Healthy Workplace for All)
1. Transparent	5. Internal management for	9. Internal management for building a
management, good	building a happy workplace	healthy workplace for all (30 points)
governance, and non-	(50 points)	10. Promoting education, public
infringement of law		health, and waste management
(50 points)		(20 points)
2. Participatory planning	6. Work of social infrastructure	
(20 points)	(20 points)	
3. Succession planning	7. Support of agricultural career	11. Developing natural resources and
(15 points)	and community enterprises	environment (20 points)
	(15 points)	
4. Support of work physical	8. Social and cultural work.	12. Activities for reducing social
infrastructure	(15 points)	problems and increasing social
(15 points)		welfare available (30 points)
100 points	100 points	100 points

Figure 2: Indicators of three-level SEP for this research.

studied the LAOs' operations according to a new model of local governance, the SEP principle, and the King Rama IX's Working Philosophy in the eastern region. The study shows that each LAO could develop its own model of local governance, by mixing the new with the old philosophy. There are five models developed:

**•••••**•••

1. Model of local governance leading to the dissolution of political power. This model was obtained from the method of lessons learned in Klong Plu Subdistrict Municipality. It shows that local executives are able to break down the political polarization between the subdistrict headman ('kamnan' in Thai) and the chief executive of the SAO: resulting in overcoming their conflict and polarization. The subdistrict headman or village headman ('puyaiban' in Thai) are unable to send his/her representative to the election field against the chief executive because of his popularity with the people towards the work. In conclusion, in order to drive towards this local governance model, it is necessary to breakdown such political power of various parties and applies the three important principles of King Rama IX's Working Philosophy, namely topographical and sociological approach, honesty and sincerity, and self-supporting.

2. Model for applying the SEP and the King Rama IX's Working Philosophy to the old localism. This

model was derived from the lesson learned in Khlong Hinpoon SAO, Koh Wai SAO, Ban Phra SAO, and Bo Phloi Subdistrict Municipality. The model shows that The LAOs have adopted the old style of local administration, namely local governance in accordance with the decentralization policy of the Constitution B.E. 2540 (1997), with the important characteristics based on a liberal democratic ideology valuing too much to the election of representatives for becoming local administrators. Therefore, there is the legitimacy of local politicians to make the final decisions because they have already acted as representatives of the people. According to this model, the level of people participation is no more than just giving opinions. This style of traditional decentralization government is more focused on local governments than local community or civil society organizations. The main objective of this model is to let the LAO operate public work primarily for the people in the community. As a result, in order to follow this local governance, the four important principles of King Rama IX's Working Philosophy should be followed, namely economy and simplicity with maximum benefits, honesty, integrity and sincerity, knowing, loving and uniting ('ru rak samukki' in Thai), and topographical and sociological approach.

3. Model of the chief executive who wins the villagers' heart. This model of local governance was ob-

Table 1.	Levels of the	SEP for e	ach of all	15 LAOs in	this study
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LADo	Sufficiency Economy Philosophy						
LAOS	Sustainable Workplace (100 points)	Happy Workplace (100 points)	Healthy Workplace (100 points)	Total (300 points)	Level of Sufficiency Economy		
1. Khlong Phlu Municipality	95	95	78	268	understand		
2. Bang Sa Kao SAO	94	88	76	258	understand		
3. Khlong Hinpoon SAO	85	83	77	255	understand		
4. Ban Song District Municipality	89	85	79	253	understand		
5. Takad-ngao SAO	89	87	74	250	understand		
6. Koh Wai SAO	86	81	79	246	understand		
7. Ban Phra SAO	82	78	74	234	understand		
8. Bang Klue SAO	84	76	80	230	understand		
9. Chanthaburi PAO	82	78	64	224	understand		
10. Huai Raeng SAO	84	67	60	211	Qualified		
11. Noen Kho Subdistrict Municipality	85	67	51	203	Qualified		
12. Koh Chang Tai Subdistrict Municipality	80	55	42	180	Qualified		
13. Bo Phloi Subdistrict Municipality	84	48	49	175	Qualified		
14. Samaesarn SAO	77	32	51	160	Not qualified		
15. Koh Mak SAO	67	43	24	134	Not qualified		

tained through lessons learned in Ban Song Subdistrict Municipality. The model shows a positive local governance process that results in dominating people's hearts. On the basis of the active management for the common, the LAO adheres and links to their community network and emphasizes villagers' participation at the level of joint decision making. It is obvious that the chief executive can win the hearts of the villagers because of his/her good work evidence. Obviously, in Ban Song in the past two decades, there have been no rival in election of the SAO chief executive. In promoting this model of local governance, the local executives should apply three principles of King Rama IX's Working Philosophy. These are honesty, integrity and sincerity, common interest, and people participation.

4. Solidarity model of local governance. This model was derived from the lesson learned in Takadngao and Huai Raeng SAOs. The results show that after the electoral competition process in these two SAOs and the winner becoming the chief executive, s/he invites his/her competitors for taking part in informal consultations on SAOs' operations, for example, organizing a coffeehouse forum on public affairs in the village, etc. In order to promote the solidarity model of local governance, the three principles of King Rama IX's Working Philosophy should be applied These are common interest, people participation, and knowing, loving and uniting (*'rurak samukki'* in Thai).

5. Model of local governance in PAO that embraces the SEP for its operations. This model is obtained from the lesson learned in Chanthaburi PAO. The model shows that organizing a local management system needs to focus on collaboration between the PAO and other relevant partners—including other LAOs, community organizations, and provincial government agencies-by adopting the SEP and the King Rama IX's Working Philosophy as a political stand and as a guideline for their operations. For example, Chanthaburi PAO holds on a political standpoint of non-aligned or nonpartisan political entity, adheres to the concept of SEP, promotes the projects derived from the speech of His Majesty the King in the area, supports the infrastructure development projects, contribute to economic problem-solving of the people in the province, including exchange of goods between provinces, etc. In order to drive this model of local governance, the four important principles of King Rama IX's Working Philosophy should be applied. These are Knowing, Loving and Uniting ('rurak samukki' in Thai), economy and simplicity with maximum benefits, topographical and sociological approach, and people participation.

#### 5. Conclusion and Recommendations

The research aims to study the politics of reconciliation and new local governance through applying the SEP and the King Rama IX's Working Philosophy in the eastern region. The study used integrated methodologies of mixed methods, case study, and lessonlearned method. 15 cases of LAOs were selected for the study. For the levels of the SEP practice fitting in the LAOs' operations, the study reveals that nine of them attain the level of understanding and obtain happy workplaces; while four LAOS are at moderate degree-or a level of being within the scope of the SEP and being sustainable workplaces. Finally, the last two cases are not fit in the scope of SEP practices. Additionally, the research proposes five models for LAOs' political driving, which are 1) model of local governance leading to the dissolution of political

power, 2) model for applying the SEP and the King Rama IX's Working Philosophy to the old localism, 3) model of the chief executive who wins the villagers' heart, 4) solidarity model of local governance, and 5) model of local governance in PAO that embraces the SEP for its operations.

According to this study, there are some recommendations as follows:

1. In order to develop towards a sustainable workplace, the LAOs should emphasize the importance of good governance in their management and succession planning.

2. In order to develop towards a happy workplace, the LAOs should focus on their internal management to encourage staffs' know how to treasure unity (*'rurak samukki'* in Thai), rejoice with others in their happiness or prosperity (*'mutita-chit'* in Thai), and maintain a calm state of mind and attitude to life ('xubekkha' in Thai).

3. In order to develop towards a healthy workplace for all, the LAOs should reduce their expenditure, especially salary, wage, and unnecessary expenses, in order to increase saving and use for the development of healthy lives for all of their local community members.

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# Assessment of genetic diversity of Wua-lan in Thailand

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# Abstract

Wua-lan (Khao-Lan) is one of the indigenous cattle (Bos indicus) in Thailand that needs immediately scientific data of animal breeding plans for this cattle management. Genetic characterization is the first step in the development of proper management strategies for preserving genetic diversity and preventing undesirable loss of alleles. Thus, in this study, we investigated genetic diversity and relationship of Wua-lan among different areas using 20 microsatellite markers. In this study, the analysis of autosomal DNA was performed on 76 Wua-lan which exhibited sufficient diversity across all the areas. The mean observed heterozygosity across all loci in this population was 0.484. Wua-lan had the allele size larger than both Thai native cattle (CSSM66 and TGLA153) and domestic cattle (BM6117 and CSSM66), but some allele size of domestic cattle (BM6445) was larger than Wua-lan. The genetic diversity was identified by expected heterozygosity (He), observed heterozygosity (Ho) and inbreeding coefficient (f) that was identified by areas as follows: Phetchaburi (0.546, 0.484 and 0.126), Ratchaburi (0.532, 0.478 and 0.134) and Prachuap Khiri Khan (0.508, 0.488 and 0.067), respectively. The Ho and He did not show differences between each area (*Ae-Ho*), the Wua-lan in Phetchaburi was the most different value, and Wua-lan in Prachuap Khiri Khan was the lowest difference value. The total of the observed heterozygosity and inbreeding coefficient ( $\frac{1}{2}$ ) of Wua-lan in 3 areas were equal to 0.484 and 0.129. A broad variation of inbreeding coefficient (f) was found among all loci, ranging from -0.875 (CSSM66) in Phetchaburi to 0.894 (BM848) in Ratchaburi Province. The genetic differentiation of Wua-lan ranged from 0.930 (Rat-Pet pair) to 0.965 (Pra-Pet pair) that was genetically differentiated by a similar magnitude. The shortest of Nei's genetic distances was observed between the Wua-lan from Ratchaburi (Rat) and Phetchaburi Province (Pet) (0.072) followed by Wualan from Prachuab Khiri Kahn (Pra) and Phetchaburi Province (Pet) (0.036). The Wua-lan from Prachuap Khiri Khan Province (Pra) was the most distant population, displaying the largest of Nei's genetic distances (0.119) when compared with the Wualan from Phetchaburi Province (Pet). The bootstrap values among this breed ranged from 2.99 to 4.78. Thus, the low values in this study were caused by the high genetic similarity between areas of animal husbandry. This result of the change in interred clusters  $(\triangle K)$  values peaked at K=4, which exhibited a reliable grouping pattern. These points suggest a distant relationship between the populations of a single geographic area, with minimal appearance of shared genetic materials between the three areas. The finding in the current study point origins of Wua-lan in Phetchaburi, Ratchaburi, and Prachuap Khiri Khan and their close relationship has been supported, in this study that showed relatively more admixture within the west region of Thailand.

Keywords: microsatellite, observed heterozygosity, inbreeding coefficient

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# 1. Introduction

Over 20 years ago, livestock production in Thailand was switched from backyard systems to industrialized husbandry by introduction of highly productive breeds [1] [2]. Thus, the population of indigenous animals has not been concerned and consequently their populations have been steadily declined. Demographic

pressures have been not only accelerated to the loss of advantage traits or decrease in population of local breeds, but also, in relation to less biodiversity [3]. Naturally, indigenous livestock commonly is a reservoir of genes such as genes resistance of tropical diseases, external parasites, and utilization of the sustenance on low quality of feed [4]. The study of the benefit local livestock genes would be valuable for future researches [3] [5]. FAO [6] reported

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that the cattle are the species with the highest number or reported extinct species (209 species). Wualan is one breed of native cattle in Thailand which are presently a small number of population and dwells in the west region-Thailand, that is very popular in Phetchaburi, Ratchaburi, Prachuap Khiri Khan and there are some in Kanchanaburi; Supanburi, Samut Sakhon, and Nakhon Pathom. The local breed characteristic is under changed over time, as a consequence of their adaptation to local environment. Thai cattle breed is classified to zebu cattle (Bos indicus) that has been evolved over centuries under low levels of selection following with traditional animal husbandry. In the past, Wua-lan was used as labor and during postharvest rice. They were then tied to the poles arranged in a row in front ground, and encouraged to trample on the rice helped separate the grain from the ears. This activity of tying the Wua-lan to the poles developed the traditional culture of cow racing. Evidently, cow racing will take place after post-harvest rice every year. Regarding the estimation of Wua-lan population in Phetchaburi Province, 73% of beef cattle farming are Thai-native cattle which are approximately 93,962 cattles [7]. Due to a small number of Wua-lan population, inbreeding will cause decreased their numbers. Consequently, their genetic diversity has been disappearing. Moreover, the Who-Lan cattle population has been decreasing due to the impact of crossbreed with exotic cattle which have been imported to farm in the west of Thailand. Therefore, genetic resource is important for managing animal breeding program and prevention of inbreeding that is reduced the genetic variability, fertility, and survival rate, which lead to an increase in the extinction risk [8] [9]. Microsatellites markers have been widely used as a marker of molecular genetic for studying conservation genetics, investigating forensic identification, profiling DNA fingerprints [8] [10] [11][12]. Microsatellites have been effective in evaluating differences of highly discriminatory at the individual level to genetically similar groups (population, breed, or species level) and still constitute the classical markers for identification and pedigree testing. There are now more microsatellitebased studies to develop probabilistic approaches for breeding plans in livestock such as pigs, wild boar, cattle, and sheep. The approaches described to obtain breed or variety assignments are generally based on the fact that different breeds or varieties can have differences in the frequencies of fixed alleles[13]. The aim of this study was to investigate the genetic diversity and structure of Wua-lan, using microsatellite marker information, to gather baseline information essential to design an appropriate conservation strategy.

# 2. Materials and Methods

# Animals and Sample collection:

Genomic DNA was extracted from blood samples of 76 Wua-Lan. They have been maintained from Central of Thailand: 16 from 5 farms in Ratchaburi Province, 40 from 8 farms in Phetchaburi Province, and 20 from 4 farms in Prachuap Khiri Khan. Blood samples were collected from jugular vein in 5 ml of EDTA blood sample and kept at -20oC until DNA extraction.

# DNA extraction:

Genomic DNA was isolated from blood using Phenol-chloroform method as described by [14]. Concentration and purity of the extracted DNA was measured using a spectrophotometer (SmartSpecTMPlus Spectophotometer, BIORAD, USA).

# DNA amplification:

Twenty microsatellite markers for domestic cattle were used for this study (Table 1) [15]. Research reported the efficacy of 20 microsatellite primers for Wua-lan that the polymorphism informative content values (PIC) of each locus were 0.135-0.813 and the average PIC was 0.504. Although, a PIC higher than 0.6 indicates high polymorphism and can be used to characterize individuals, a value of average PIC value between 0.30-0.59 is considered to be moderated informative [16]. Therefore, 20 microsatellite primer studies were sufficiently efficient for use in the study of the genomicity of Wua-lan. These microsatellite markers were spread all over the genome and with the ability to co-amplify in PCR reactions [17]. Twenty microliters of the PCR mixture (Invitrogen®, Brazil) was composed of 50 ng of DNA template, 2  $\mu$ l of PCR buffer (10xbuffer), 1 µl of 50 mM MgCl2, 0.4  $\mu$ l of 10 mM dNTPs, 0.1  $\mu$ l of each forward and reverse primers (100  $\mu$ M), 0.1  $\mu$ l of Taq DNA polymerase and DNase-free water. The PCR conditions were modified from those described earlier. An initial denaturation at 94°C for 3 min; followed by 35 cycles of 94°C for 30s, 58°C for 30s, and 72°C for 45s and a final extension at 72°C for 5 min. The PCR products were electrophoresed using 1.5% agarose gel (ADVANCE, Japan) and visualized under ultraviolet illumination. DNA fragment analysis from the separation of amplified PCR product of twenty microsatellite DNA by capillary gel electrophoresis using QIAxcel device with BioCalculator Analysis Software (Qiagen Inc., Valencia, CA, USA).

# Statistical analysis:

The size of alleles for cattle loci was analyzed using PowerMarker Version 3.25. Genetic diversity, often referred to as He, is defined as probability with randomly chosen alleles from the differenpopulation.

Heterozygosity is referred to as the Ho. The inbreeding coefficient  $(\frac{1}{2})$  is relative measure, in that there will be a certain level of homozygosity within the population and it estimates the increase from that initial level as a result of recent inbreeding. Nei's unbiased measures of genetic identity and genetic distance of three populations of Wua-lan were estimated using POPGENE 32, following [18] [19] [20]. The most popular model-based clustering technique was STRUCTURE program [21] [22] [23]. The STRUC-TURE analysis at the chromosomal level to investigate genome-wide distribution of the Wua-lan backgrounds among the population and assumes a model with Kpopulations; K may be unknown. It is assumed that within populations loci are in linkage equilibrium and Hardy-Weinberg equilibrium; STRUCTURE program assigns individuals to populations to achieve this.

### 3. Results and Discussion

All 20 microsatellite markers for domestic cattle could be assessed for the genetic diversity of 76 Wualan. From previous study, Arlai et al., [14] found a total of 110 alleles of Wua-lan (Phetchaburi, Ratchaburi and Prachuap Khiri Khan) by analysis on the basis of the same microsatellite markers, with average allele equal to 5.5 alleles per position. The main allele frequencies (MAF) were ranging from 0.225 to 1.000 and one of this MAF, BM6445 has MAF equal to 1. Only 1 allele was found monomorphic in cattle from Ratchaburi. The total number of alleles found in each local area from all used to study ranged from 1-9. Mean alleles of all 20 loci in Wua-lan were found the lowest at 4.100 alleles in Ratchaburi and the highest at 4.950 alleles in Phetchaburi. The average PIC was 0.504. The genetic markers in this study showing PIC values higher than 0.5 are normally considered as informative in population genetic analyses (Botstein et al., 1980). Next, the present studies were found the size of these allele sizes for locus as shown in Table 1. In this study, Wua-lan had the allele size larger than both those of Thai native cattle such as Kho Lan (Wua-lan), Kho Khaolumpoon, Kho Isaan, and Kho Chon (CSSM66 and TGLA153) [24][25] and domestic cattle (BM6117 and CSSM66) [17][26] but some allele size of domestic cattle had larger than (BM6445) Wua-lan. These loci of Who-lan cattle showed different alleles with no overlapping size ranged for other Thai native cattle and domestic cattle. The previous report by Duangjinda and Phasuk [25] conducted the analysis on the basis of the same microsatellite markers (BM6117, ETH225, CSSM66 and TGLA53). The obtained results are different that could probably be explained by the higher number of samples and also wide-ranged sampling localities in the present study [27]. Part of other microsatellites remain in these studies were overlapping all in domestic cattle. So, these markers are highly conserved in Bovidae.

The genetic diversity was identified by *He*, *Ho* and f values. The averages of the Wua-lan genetic diversity (expected heterozygosity; He), heterozygosity (Observed heterozygosity: Ho) and inbreeding coefficient (f) that was justified by areas are as follows: Phetchaburi (0.546, 0.484 and 0.126), Ratchaburi (0.532, 0.478 and 0.134) and Prachuap Khiri Khan (0.508, 0.488 and 0.067), respectively. The Ho and He did not show differences between each local (△He-Ho, Total observed heterozygosity and inbreeding coefficient (f) of Wua-lan in 3 areas, the values were equal to 0.484 and 0.129, respectively. The results in each locus are shown in Table 2 and figure 1. In general terms, all of the areas presented moderate genetic diversity. The observed heterozygosity was lower than the expected heterozygosity in every area: in Phetchaburi, the Ho value (0.484) ; He value (0.546); in Ratchaburi, the Ho value (0.478); He value (0.532) and in Prachuap Khiri Khan, the Ho value (0.488); *He* value (0.508). The *Ho* value lower than He value meant the strong condition of Hardy-Weinberg disequilibrium found for the majority of the loci analyzed, which may reflect the narrow genetic base of the current population of this breed [27][28]. According to Sharma et al., [3] it found the observed value (0.459) and expected heterozygosity (0.594) in Ongole cattle. While in the previous studies, the overall He and Ho of Thai native cattle were ranged from 0.79-0.85 and 0.17-0.31, respectively. He and Ho values of Wua-lan were equal to 0.8 and 0.17, respectively. But, for this study, the He of Wua-lan was lower and the Ho was higher when compared to the study of Duangjinda and Phasuk, [3]. Sharma et al., [3] found that Shahabadi cattle breed had the highest heterozygosity values of Indian cattle (0.735), which could be explained by the occurrence of low selection pressure due to the lack of breeding programs. Moreover, in the past, the gene flows between different populations and a large number of alleles were presented in all breeds [29]. While, happen in Tharparkar cattle in India (0.64) [30], Orissa cattle (0.62-0.66) in India [31], Creole cattle in Brazil (0.61) [32] and Chinese cattle (0.62) [33]. However, the differences in the estimates can also attribute to the different numbers of markers and/or individuals analyzed [34]. It is also relevant in a long-term perspective, as selection limits are determined by the initial allelic composition rather than by heterozygosity [35]. The inbreeding coefficients were derived from an additive relationship matrix for the whole population and within the above-mentioned genetic groups [36]. The total  $\oint$ value of Wua-lan, in this study was higher than zero (0.129). A broad variation of inbreeding coefficient (f) was found among all loci, ranging from -0.875 (CSSM66) in Phetchaburi to 0.894 (BM848) in Ratchaburi. Highly heterozygote deficit of Wua-lan of all of the 3 populations investigated were the highest in Ratchaburi (0.134), followed by Phetchaburi (0.126)

Microsatellite loci	Allele size range (bp)						
wherosateline idei	Domestic cattle1	Thai native cattle <sup>2</sup>	In this study				
		Kho Lan (Wua-lan), Kho Khaolumpoon, Kho Isaan, and Kho Chon	(Wua-lan)				
BM1824	176-197	-	180-204				
BM2113	116-146	123-147	140-158				
INRA023	195-225	-	202-230				
BM1260	120-133	-	128-146				
ILSTS006	277-309	-	274-308				
BM6117	110-114	-	124-146				
ETH225	131-159	140-160	153-187				
BM1237	187-223	-	195-223				
BM6445	159-175	-	143-153				
BMC1222	272-302	-	276-324				
CSSM66	171-129	154-174	192-232				
BM848	215-227	-	219-245				
TGLA53	143-191	119-153	158-184				
TGLA126	115-131	-	117-151				
TGLA122	137-173	-	140-176				
BM1818	258-272	-	245-295				
BM226	128-164	-	142-182				
BMC8012	197-215	-	205-229				
BM2515	132-148	-	144-158				
BM6436	198-208	-	198-226				

Table 1. Characteristics of allele sizes in domestic cattle and Thai native cattle.

<sup>1</sup>From FAO, 2011; Bishop et al., 1994

<sup>2</sup>From Mekchay et al., 2007; Duangjinda and Phasuk, 2008

and Prachuap Khiri Khan (0.067) respectively. This is consistent with the study of Colombian creole cattle, which was higher than zero, indicating a general deficit of heterozygous individuals in all analyzed local areas of animal husbandry [34]. Possible heterozygous deficit factors may include inbreeding, selection of small number of populations in each generation, or mating among closely related animals [3] [27] [37]. From the interviews with farmers, the breeder of Thai native animals is the main factor with genetic variation effect in Thai native animals. One of them was Wua-lan that the mating choice decided by the breeders such as mating between close relatives with a few superior animals (father and mother). Over reproduction in Wua-lan populations without control is the main cause attributed to inbreeding. Due to the fact in most Thai native cattle farms, crossed breeding with no records or controls are frequently occurred in related animals. This style of breeding leads to a decrease of heterozygous individuals in the population. Therefore, a higher inbreeding rate has been reported for dairy cattle populations [38] and horse populations [39], leading to increased precision of inbreeding evaluation, although the inbreeding coefficients were relatively low [40]. The positive effects of inbreeding may have been due to the purging of deleterious alleles in previous generations [41]. Moreover, several farmers said that some part of Wua-lan herds in the country has usually dominated by one or two sires over the entire herd, the above actions may increase the proportion of homozygous alleles that decrease *Ho* and increased  $\oint$  value in the population with the consequent decrease in the genetic variability of herds [29]. Most of Thai native animals' gene pools were limited in a local area and most of them can be found inbreeding of Thai native animals. Therefore, the opportunity of the new gene transfer into a population is usually limited [42]. In addition, the racing males of Wua-lan are castrated around the age of one year leading to a decrease of their gene in the population. Thus, the paucity of pure bulls, as well as management, seems to be the main reasons for heterozygote deficiency in these cattle.

#### Genetic Differentiation and Genetic Distance

The genetic differentiation and Nei's genetic distance pairwise estimates between Wua-lan areas of animal husbandry (Phetchaburi, Ratchaburi, and Prachuap Khiri Khan Province) which the corresponding genetic tree was created using the neighbor-joining algorithm. The genetic differentiation between areas of animal husbandry is presented in Table 3. The genetic differentiation range of Wua-lan was from 0.930 (Rat-Pet pair) to 0.965 (Pra-Pet pair) by a similar magnitude. The shortest of Nei's genetic distances was observed between the Wua-lan from Ratchaburi (Rat) and Phetchaburi Province (Pet) (0.072), followed by Wua-lan from Prachuap Khiri Khan (Pra) and Phetchaburi Province (Pet) (0.036). The Wualan from Prachuap Khiri Khan Province (Pra) was the most distant population, displaying the largest of

**Table 2.** Observed heterozygosity, Expected heterozygosity and Inbreeding coefficient of 20 microsatellite markers in bovine from Phetchaburi (Pet), Ratchaburi (Rat) and Prachuap Khiri Khan Province (Pra).

Marker	Observed heterozygosity (Ho)		Expect	Expected heterozygosity (He)			Inbreeding coefficient $(f)$		
	Pet	Rat	Pra	Pet	Rat	Pra	Pet	Rat	Pra
BM1824	0.250	0.313	0.200	0.598	0.643	0.545	0.590	0.537	0.648
BM2113	0.500	0.625	0.450	0.569	0.607	0.441	0.134	0.003	0.006
INRA023	0.600	0.375	0.550	0.676	0.451	0.489	0.125	0.200	-0.100
BM1260	0.100	0.375	0.100	0.095	0.477	0.095	-0.040	0.244	-0.027
ILSTS006	0.550	0.750	0.600	0.685	0.732	0.736	0.209	0.008	0.210
BM6117	0.500	0.438	0.200	0.381	0.342	0.180	-0.301	-0.250	-0.086
ETH225	0.625	0.625	0.650	0.698	0.611	0.550	0.117	0.010	-0.157
BM1237	0.650	0.438	0.800	0.707	0.520	0.705	0.093	0.189	-0.109
BM6445	0.150	0.000	0.300	0.139	0.000	0.255	-0.068	NaN	-0.152
BMC1222	0.600	0.313	0.450	0.719	0.660	0.540	0.178	0.550	0.191
CSSM66	0.975	0.938	0.950	0.524	0.529	0.499	-0.857	-0.758	-0.900
BM848	0.175	0.063	0.150	0.490	0.557	0.229	0.650	0.894	0.367
TGLA53	0.425	0.375	0.450	0.456	0.322	0.520	0.080	-0.132	0.160
TGLA126	0.575	0.625	0.450	0.492	0.557	0.469	-0.156	-0.091	0.066
TGLA122	0.700	0.688	0.750	0.833	0.762	0.833	0.172	0.129	0.124
BM1818	0.550	0.375	0.500	0.584	0.486	0.644	0.070	0.259	0.248
BM226	0.775	0.875	0.700	0.758	0.770	0.641	-0.010	-0.105	-0.066
BMC8012	0.400	0.500	0.450	0.740	0.725	0.754	0.469	0.339	0.424
BM2515	0.250	0.438	0.550	0.219	0.342	0.399	-0.130	-0.250	-0.357
BM6436	0.333	0.429	0.500	0.560	0.541	0.644	0.415	0.243	0.248
Mean	0.484	0.478	0.488	0.546	0.532	0.508	0.126	0.134	0.067

NaN= Not a number

Nei's genetic distances (0.119) when compared with the Wua-lan from Phetchaburi Province (Pet).

# bandry.

The dendrogram of genetic distance matrix generated by UPGMA method[43] as well as bootstrapping proportions are shown in Figure 3. The Wua-lan is Bos indicus specie. In this study, Wua-lan are all within the same cluster. The genetic tree shows the different between Wua-lan from Ratchaburi, Phetchaburi, and Prachuap Khiri Khan. For Wua-lan breed of Prachuap Khiri Khan Province, the most distant breed could be observed when compared to Wua-lan breed of Ratchaburi Province. However, Wua-lan in Phetchaburi and Prachuap Khiri Khan are grouped under the same node, and this genetic closeness could be explained considering that both area exchange their genetic material. In the past, the breeder of Whua-Lan cattle in Phetchaburi and Prachuap Khiri Khan might share certain geographical areas of the Wua-lan territory, which might have favored genetic exchange between them. While breeders of Whua-Lan cattle in Ratchaburi might choose local breeders rather than from other areas. Wua-lan are spread in a large number of small herds in three different areas. The large within-herd mean relationship and low effective population size warn that inbreeding must be kept under control, by avoiding mating among close relatives and rotating animals among herds. The bootstrap values among this breed ranged from 2.99 to 4.78 (Figure 2). Thus, the low values in this study were caused by the high genetic similarity between areas of animal hus-

# Population structure

This research used model-based clustering implemented in STRUCTURE to partition the genetic of each region of animal into a predefined number of clusters. As shown in Figure 3, for predefined K = 2, K = 3, and K = 4 populations of Wua-lan were clearly clustered into Phetchaburi, Ratchaburi, and Prachuap Khiri Khan provience, individual cattle were assigned to the given population, which was identified by color. Wua-lan is classified as a Zebu type. This result of change in intered clusters  $(\triangle K)$  values peaked at K=4, indicating strong support for three populations. Each population area was independently assigned to its inferred cluster despite some evidence of admixture. These points suggest a distant relationship between the populations of a single geographic area, with minimal appearance of shared genetic materials between the three areas, hence indicating that Wua-lan from all populations have been very low levels of gene flow between the three areas. The finding in the current study point origins of Wua-lan in Phetchaburi, Ratchaburi, and Prachuap Khiri Khan. Their close relationship has been supported, in this study, that showed relatively more admixture within the central region of Thailand. This result may be due to the phylogenetic relationships between these breeds and/or migration of individuals between the different farms located in the distribution area of the different populations. Al-



### **Observed Heterozygosity and Inbreeding Coefficient**

Figure 1: Observed heterozygosity and inbreeding coefficient of Wua-lan in Phetchaburi Province (Pet), Ratchaburi Province (Rat), Prachuap Khiri khan (Pra), and a total of three provinces.

Table 3. Nei's genetic differentiation (above diagonal) and genetic distance (below diagonal) of cattle from Phetchaburi (Pet), Ratchaburi (Rat) and Prachuap Khiri Khan Province (Pra).

Pop ID	Pet	Rat	Pra
Pet	***	0.930	0.965
Rat	0.072	***	
Pra	0.036	0.119	***

though, the Thailand government created conservation plans for native cattle such as Wua-lan breeds though the Department of Livestock development. Nowaday, there is no conservation program in the country for Wua-lan and other native breeds. For this reason, the number of pure native breeds has been reduced over time. This situation could threaten the survival of the purebred and should be concerned.

In conclusion, using neutral microsatellites markers showed a level of genetic diversity in Wua-lan population despite its had selective breeding by the breeder. Previous studies on the genetic diversity of Wua-lan have been limited to only one population [25]. However, no study has been done at the genetic level; hence necessitated the need to assess the genetic diversity of all existing Wua-lan. Wua-lan are indigenous cattle that are adapted to the tropical environmental condition, utilized by poor quality grazing, parasite infestation, and challenges of tick-borne diseases. However, Wua-lan is clustering solutions of sharing of diversity and present of genetic structure between the populations of a single geographic area. Moreover, inbreeding was detected in some provinces, suggesting the need for appropriate measures to avoid the negative effects. The results presented here can acknowledge all stakeholders. A wide range of genetic diversity is required in the future for generating transgressive variation for providing a valuable source of genetic material that may be used for meeting the demands of Wua-lan breeding programs. Thai native cattle breeders in Thailand did not have a scientific data system for mating and breeding selection. However, it raises the awareness to conserve the pure Wua-lan breed. The information on the inbreeding situation should be provided to the Thai native cattle breeders in order to collaborate together to prevent inbreeding depression in

the future. Moreover, crossbreeding with free-ranging domestic cattle or Thai is usually an accidental finding especially in the urban area. If the owner ignore it, it was one of the main threats to their purebred status. Breeding management and pedigree recording should be considered to prevent the incorporation of native cattle genes into the Thai purebred cattle gene pool, avoid future inbreeding, and maintain their genetic integrity [44]. It is anticipated that such knowledge will not only help to develop the value of Wua-lan populations as an indigenous animal genetic resource, but will also contribute towards informed livestock production improvement strategies, to ensure national food security and enhance economic growth.

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Figure 2: Dendrogram of genetic distance between Whua-Lan cattle from (Phetchaburi) (Pet), Ratchaburi (Rat) and Prachuap Khiri Khan (Pra).



**Figure 3**: Population structure and membership fraction at K = 4, K = 3 and K = 2 for 76 accessions of Wua-lan base on microsatellite markers analysis (Phetchaburi Province: 1(1) - 40(1), Ratchaburi Province: 41(2) - 56(2) and Prachuap Khiri Khan Province: 57(3) - 76(3)). Each column accession generated by cutting the Ward dendrogram into a specified number of clusters/groups; the numbers of clusters from top to bottom were 2, 3, and 4. The clusters are represented by different colors.

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